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Founded as Metal Industry, January, 1903 by Paimer H. Langdon, 1868-1935

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#### Published Monthly by

#### FINISHING PUBLICATIONS, INC.

founded 1903 as

Metal Industry Publishing Co., Inc.

11 West 42nd St. New York 18, N. Y. Telephone: PEnnsylvania 6-0226

also publishess of

also publishers of Organic Finishing, monthly, \$1.00 per year Guidebook-Directory for the Metal Finishing Industries, annually, \$1.50





Copyright 1948 by Finishing Publications, Inc. Entered February 25, 1903, at New York, N. Y., as second class matter under Act of Congress, March 3, 1879. Re-entered as second class matter June 13, 1940, at the post office at New York, N. Y., under the Act of March 3, 1879.

SUBSCRIPTION PRICES: United States, \$3.00 and Canada, \$3.00 per year. Other countries \$7.50. Single copies 35c in U. S. and Canada, Foreign 75c. Please remit by check or money order; cash should be registered.

Contributed articles, communications, etc., on pertinent subjects are invited. Their publication, however, does not necessarily imply editorial endorsement.

AUGUST, 1948

VOLUME 46 • NUMBER 8

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#### COMING SOON

An article describing the colorimetric determination of small amounts of Zinc in Bright Nickel Plating baths.

The design of special cells for the control of plating baths. Several novel types of cells, together with a discussion of their value, will be covered.

The effect of the type of sealing treatment used on the effectiveness of the corrosion resistance of anodized coatings on Aluminum.

Another in the interesting series of discussions on fluid mechanics as it affects electroplating.

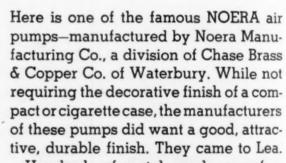
A photographic visit to a plant where galvanizing is done in large quantities for small parts that are handled almost entirely in baskets.

## METHOD COMPOUND

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UME 46

## Wanted-Plating Salesmen

During a recent "over-the-fence" backyard conversation with the next door neighbor, possessor of one of the new post-war automobiles, he remarked (between grunts as he worked vigorously at the bright trim on his car) that "some day a smart guy would come along with a metal that would last on automobiles, then all you platers would be looking for new jobs."

The double intention of his remark was obvious, but the one disturbing thought that struck me from this conversation was that, all our advanced techniques to the contrary, the consuming public is still not sold on plated finishes!

A horrible thought? Not when the facts are considered from the viewpoint of the consumer who is not acquainted with the plating industry and its problems, and sees only the multitude of defective plated items that come under his observation from day to day. Here, for instance, was a case where the plated "bright-work", after only two years service, was not equal in appearance to the painted portion of the automobile, and many signs of rust and blistering were in evidence. No wonder the consumer is anxiously awaiting the magic discovery to end this nuisance!

The serious inroads made by stainless steel, in spite of its own shortcomings, into the automotive trim field should be ample evidence of this type of thinking.

It seems as though the concerted efforts of the entire plating field should be directed towards dispelling this all-to-common belief that plated finishes are only substitutes, and will not stand the test of time. This is a selling job that will take a long time and a lot of effort, but one that is of utmost importance to the industry.

The best "salesman" will always be a top-quality plating job on every item. Any process is judged more on its failures than on its successes, and there is no more reason to expect the consuming public to be any more sympathetic towards inferior plating than it is toward any other inferior product.

S. S. Johnston Supreme President

Arthur Logozzo Supreme First Vice-President



William J. Neill Supreme Second Vice-President

# New National Officers Elected at Annual Convention Meeting

At the Annual Meeting held during convention week at Atlantic City the new officers of the Supreme Society were elected for the coming year: Samuel S. Johnson, Technical Director of the Electrolytic Dept. of the Weirton Steel Co. was elected Supreme President, succeeding Kenneth M. Huston; Arthur W. Logozzo was elected Supreme First Vice-President, Mr. Logozzo is president of the Nutmeg Chrome Corp. The new Supreme Second Vice-President is William J. Neill, General Supt. of the Columbus Metal Products Co. The newest member of the National Officers group is C. F. Nixon, Director of Process Engineering at the Fisher Body-Ternstedt Div. of General Motors, as Supreme Third Vice-President. Dr. A. Kenneth Graham was again elected Executive Secretary. Dr. Graham is President of Graham, Crowley & Associates, Inc.

The new President is a graduate of

the College of Engineering of Ohio State University, and was connected with the Carnegie-Illinois Steel Co. and the U. S. Bureau of Mines before joining Weirton Steel Co. He is a member of the Electrochemical Society, The American Institute of Chemical Engineers, and the American Society for Testing Materials.

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Fire Second Second to This

Mr. Nixon, the newly elected Third Vice-President, is a graduate of the University of Wisconsin, and was formerly connected with the Western Electric Clock Co. before his present position. He has been a member of the AES for 24 years.

The Milwaukee Branch will be the hosts at the 1949 Convention, which will be held during June of next year. It was decided that there will be no exhibits at the 1949 Convention. Mr. William Geisman, of the Allis Chalmers Mfg. Co. will be the General Convention Chairman for this meeting.



C. F. Nixon Supreme Third Vice-President



Dr. A. Kenneth Graham
Executive Secretary and Business Manager

# International Fellowship Club Elects New Officers

At the recent Annual Meeting of the International Fellowship Club held at Atlantic City in conjunction with the 35th Annual Convention and Exposition of the American Electroplaters' Society, the following officers were elected to serve for the coming year:

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President—Mr. Louis M. Hague, President of Hanson-Van Winkle-Munning Co.

First Vice-Pres.—Mr. Rudy Hazucha, Sales Manager of The Clinton Co.

Second Vice-Pres.—Mr. George Nankervis, President of the Geo. L. Nankervis Co.

Third Vice-Pres.—Mr. A. P. Munning, President of Munning and Munning Corp.

Secretary—Mr. Tom Trumbour, Business Manager for Finishing Publications, Inc.

This will be the nineteenth consecutive year that Tom Trumbour has held the post of Secretary.

The Fellowship club sponsored the Annual Open House Party on the first night of the Convention in the Ballroom of the Ambassador Hotel, and everyone who attended agreed that this year's party exceeded in fun, fellowship, and entertainment any that had preceeded it in the past. The Golf Tournament held at the Atlantic City Country Club also drew a large entry of divot diggers, and the ladies were entertained at a Card party on Monday afternoon.

Winners of the golf tournament were:

1st—Dr. C. A. Escoffery, Federal Tel. & Radio Corp.

2nd—R. W. Renton, R. W. Renton Co. 3rd—L. Pivarcy, Murray-Ohio Corp. 4th—James Joyce, Sperry Gyroscope Co.

5th—Carl Schaeffer, Casco Produc's Co.

6th-Mrs. McNeilly, Bacon Felt Co.



Louis M. Hague President



Rudy Hazucha First Vice-President



T. A. Trumbour Permanent Secretary



A. P. Munning Third Vice-President



George L. Nankervis Second Vice-President

## The Physical Properties of Electrodeposits— Their Determination and Significance

By Seymour Senderoff, National Bureau of Standards, Washington, D. C.

#### Introduction

T IS surprising that, although metals are the chief concern of the plating industry, those physical properties of metals which metallurgists have considered as fundamental have only recently begun to command appreciable attention by the industry. Most of the testing of electrodeposits done at present involves either tests on the amount and continuity of deposits. such as thickness and porosity tests, or performance tests, such as salt-spray, humidity or outdoor exposure tests. The importance of these tests in evaluating electrodeposits is unquestionable, and much work has been done and still is being done on the improvement of these methods. Their limitations, however, are also evident. The first type tells merely how much deposit there is and how completely it covers the base metal, but gives no information on the intrinsic properties of the deposit. The performance tests give an indication of how a particular deposit will respond to more or less standardized methods of attack. Since all significant variables in performance tests are very difficult to control, their interpretation is doubtful unless a large number of samples are tested over a long period of time and the data treated by statistical methods. The difficulties involved in these tests are evident when it is realized that after many years there is not yet complete agreement on the method of performing and interpreting salt-spray tests. In the field of intrinsic physical properties of the deposit, only hardness and ductility have received widespread attention. Such tests, however, as the bend and twist tests are still rudimentary, and the results obtained are as much a function of adhesion to and nature of the basis metal as of the deposit itself.

It is desirable to determine the fundamental physical properties of electrodeposited metals, uninfluenced by the basis metal. When sufficient data have been collected on deposits produced under various conditions, it is expected that they will provide a basis for the prediction of the performance characteristics of electrodeposits. In addition, more detailed knowledge of these physical properties will undoubtedly lead to more fundamental knowledge of electroplates and the processes for producing them, and to improvements which always come from fundamental knowledge.

The physical properties and methods for their determination which will be treated here are those usually found in the standard reference volumes, which give the properties of bulk metals. Since an electroplate is essentially a surface, rather than a structural element of an article, it will be found that the relative importance of the various properties is somewhat different than that which they have in bulk metals. The significance of each of the properties to the general requirements of electroplates, and to particular requirements in specific applications, will be discussed, together with the most reliable methods for measuring these properties.

#### Tensile Strength

One of the richest sources of information on the physical properties of metals is the stress-strain diagram. This is obtained by stretching a properly pre-



The Author

Mr. Senderoff has been a chemist with the Bureau of Standards for 1 year, in the Electrodeposition Section. Previous to that he was associated with United Chromium for 6 years in their Waterbury and Detroit laboratories. He is a graduate of the City College of New York, and holds a Master's Degree in chemistry.

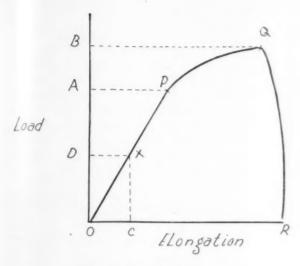


Figure 1. Stress-Strain Diagram.

pared standard specimen of the metal under controlled conditions, and plotting the load applied vs. the elongation produced, as in Fig. 1. The curve proceeds from O to P in a straight line, then with varying curvature to a maximum at Q, and falls rapidly to R.\* The curve shown here is not typical of any particular metal, but rather an idealization of the types of curves usually obtained with metals.

The most frequently quoted property given by these data is the Tensile Strength. This is a measure of the force required to pull the metal apart and is defined quantitatively as the maximum stress reached in the stress-strain diagram. It is expressed as the maximum load (OB in Fig. 1) divided by the initial cross-sectional area of the specimen. While this is essentially a structural property, it has considerable practical importance in an electrodeposit. If the basis structure can withstand distortions which are too great for the deposit, the deposit will fracture under such distortions and thereby cease to perform its function of corrosion protection, decoration, etc. at and near the points of fracture. Further, as the thickness of the deposit increases, the contribution of its own strength to that of the entire structure increases, until in electroformed articles, the strength of the electrodeposit is the strength of the structure.

#### Ductility

The area under the curve in Fig. 1 represents the work necessary to pull the specimen apart. This is a function not only of the strength, but also of the ductility of the metal. The ductility is a property whose importance has long been appreciated by electroplaters, but the methods of testing for it by bending or twisting a composite specimen consisting of a basis metal and coating are inadequate to define this property of the coating. Ductility is a fairly complicated

concept that is usually characterized by a number of properties shown by the stress-strain diagram. The property most frequently associated with ductility is the *Elongation*. This is usually expressed as percent

elongation in a specified gage Length,  $e = \frac{R}{-} \times 100$ ,

where e = % elongation

R = Total elongation when stretched to fracture (OR in Fig. 1)

L = Initial gage length of specimen

It is evident that when under influence of external forces, a deposit will not undergo dimensional distortion equivalent to that of the basis metal, severe stresses will be set up at the interface of the two metals which may be sufficient to break the bond between them, even if the forces are insufficient to fracture the metal itself. Ductility in a deposit is of prime importance when the plating is done on semi-finished products which are later subjected to forming or machining operations, and on articles whose use entails occasional or periodic deformation.

Another property associated with ductility is the Reduction in Area. At the same time that the section becomes longer during stretching, its area becomes smaller. Until point Q (Fig. 1) is reached, these two dimensional changes are occurring uniformly along the specimen. At point Q, however, the distortion becomes localized and a large reduction in area occurs at the point of fracture, resulting in the well-known "necking-down" of the specimen, as shown in Fig. 2. Since elongation is a function of the proportions of the specimen, and since the "necking-down" effect contributes appreciably to the elongation but is independent of the length of the specimen, unit elongation calculated from reduction in area data gives different values (usually much larger) than when calculated as shown above. The unit elongation calculated from reduction in area is sometimes called "effective elongation." (1) \* Reduction in area is usually given in percent by:

$$q = \frac{A_1 - A_f}{A_1} \, x \, 100, \ where$$

q = % reduction in area

 $A_i = Initial cross-sectional area of specimen$ 

A<sub>f</sub> = Cross-sectional area at point of fracture (after breaking)

The reduction in area is also important in determining the true stress-strain diagram. Since stress is the load per unit cross-sectional area, the stress at any point in the tensile-test diagram is the quotient of applied load and cross-section at that point. After point Q in Fig. 1, the reduction in area is more rapid than the fall in load; and as a result, the true stress is at a maximum at the instant of fracture, as would be expected.

### Proportional Limit and Modulus of Elasticity Another property which is determined from the

<sup>- \*</sup> Some authorities refer to this as the "tensile-test diagram," reserving the term "stress-strain" diagram for the plot of stress (load per unit cross-section) vs. strain (elongation per unit length). The ASTM, however, uses the term, "stress-strain diagram," for both,

<sup>\*</sup> Numbers in parentheses refer to bibliography at end of text.

stress-strain diagram is the Proportional Limit. This property is related to the stress-strain characteristics of a metal over a small but important portion of the range of the diagram. Referring again to Fig. 1, we note that the elongation is directly proportional to the applied load from O to P. This part of the curve therefore represents the portion in which the metal behaves as an elastic body, and on release of the load can be expected to return to its original dimensions. While there are some complicating effects, such as hysteresis and strain hardening, in general, this diagram does represent the behavior of metals. An electroplated object may be subjected to fairly small stresses which are below the proportional limit of either the basis metal or the deposit, but not of both. In this case, on removal of the external forces, either the basis metal or the deposit will tend to return to its original dimensions, while the other will not. As a result, serious residual stresses will remain in the deposit and they may be either tensile or compressive. The effect of residual stresses will be discussed later. The proportional limit is the stress at P in Fig. 1 and is evaluated as the load at P (OA in Fig. 1) divided by the initial cross-sectional area of the specimen. It should be noted here that it is somewhat difficult to find the point P exactly, since the smallest amount of departure from proportionality measured would be a function of the sensitivity of the measuring instrument. It is therefore necessary to use sensitive strain gages or extensometers to measure this property.

Young's Modulus of Elasticity may also be obtained from the stress-strain diagram. At some point, X, below P (Fig. 1) where reduction in area may be considered negligible, Young's Modulus, E, is given by:

$$E = \frac{Strain}{Stress} = \frac{\frac{OD}{A_1}}{\frac{OC}{D}}$$
, where OD and OC are defined by Fig. 1,  $A_1$  is the initial cross-sectional area, and L is the initial gage length.

Young's Modulus of Elasticity is an important physical property because it determines the slope of the curve from O to P. It can be accurately and easily measured and can serve as one means of comparing deposits produced under different conditions. Further, one or two measurements are sufficient to establish the value of the modulus and the sample is not broken or appreciably changed in structure in the determination.

While there are other structural properties related to strength and ductility which can be determined from the stress-strain diagram, the ones covered are those most important to electroplaters. The successful measurement of these properties requires rigid standardization of procedure in the preparation of samples and in conducting the tensile test. Some of the more important variables which affect the results are size and shape of the specimen, metallurgical history of the specimen (heating, cold-work, etc.), surface condition of the specimen (macroscopic scratches, notches, etc.), rate of stretching, and others beyond the scope of this paper. The ASTM and others have set up

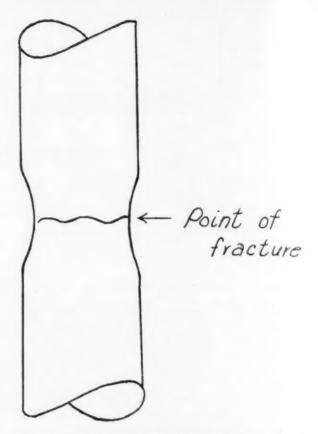


Figure 2. Stretched tensile specimen showing localized "neckingdown" at point of fracture.

detailed rigid specifications for the size and shape of the test specimens and the procedures used in testing which can be adapted, with modifications in some instances, to the testing of electrodeposits. The standard forms used are round specimens cut from bars or tubes, and rectangular specimens cut from sheet or plate. The bar specimens are not applicable to testing electrodeposits because of the mordinate thickness required. The tubular and rectangular standards are, however, readily adaptable for use with electrodeposits. In general, tubes and sheets of the metal are electroformed under carefully controlled plating conditions and then separated from the core or starting sheet. They are finally cut to standard size and stretched in one of the commercial testing machines.

#### Preparation of Samples

In Fig. 3 is shown the standard sheet specimen specified by ASTM (2) for tensile tests on sheets of thickness between 0.005 and 0.5 inch. The sheets may be electroformed by plating on both sides of a stainless steel sheet as was done by Roehl (3). The edges of the sheet are then sheared off and the two electroformed sheets either fall off or are easily pulled off. The specimen is then cut from the center of the sheet in order that a sample of uniform thickness is obtained. Other methods for electroforming sheets, which can be used when the metal under investigation either adheres too well to stainless steel or forms blisters on stainless steel, are: plating on copper and dissolving the copper with nitric acid or chromic-

sulfuric acid mixture, if the deposit is unaffected by these acids; or plating on steel and dissolving the steel in hydrochloric acid if the deposit is not attacked by this acid. If plated metal is such as to preclude the use of any of these procedures, a somewhat less satisfactory method may be used which entails the coating of a flat sheet with a wax compound, impregnating the wax surface with graphite, and plating on the graphitized wax. The sheet may then be removed either mechanically, or by the application of a little heat to melt the wax. Roehl used specimens 0.03 inch thick. He found that at or above this thickness the ductility was independent of the thickness. When testing thinner sheets, the fact that some of the physical properties may be a function of the thickness must be considered.

In Fig. 4 is shown the standard tube specimen specified by the ASTM (2). These may be prepared by plating on thin walled seamless copper tubing and dissolving the copper by immersing the tube in nitric acid or in chromic-sulfuric acid mixture and passing a slow stream of air up through the tube. An alternate procedure is to plate a thin layer (0.0001 to 0.0005 inch) of a low melting metal, i.e. lead or tin, on a rod, and then plate the metal to be tested over this intermediate layer. On heating to the melting point of the intermediate layer, the rod may be pushed out. leaving a tube of the metal to be tested. A convenient size for tensile test tubes are 1/4 to 1/2 inch diameter, 6 to 8 inches long, and 0.005 to 0.02 inch wall thickness. As shown in the diagram, tightly fitting plugs are inserted at each end and the tube gripped over these plugs.

An interesting modification of the standard procedure for testing tubular samples specifically applicable to chromium or other brittle metals was described by Brenner, Burkhead, and Jennnings (4). Since the specimen tubes were too brittle to be gripped in the testing machine without breaking, steel rods were inserted in each end and "cold-welded" to the specimen by plating with a nickel strike and heavy copper plate. The central section was stopped off during this operation to form the reduced section of the tensile specimen. Tubes prepared by this procedure are shown in Fig. 5.

#### Testing

After a specimen is prepared it is placed in any of the usual testing machines and stretched. The rate of application of the load must be carefully controlled, especially with the lower melting metals such as zinc,

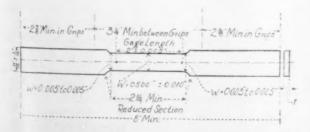


Figure 3. ASTM Standard sheet specimen, Designation E8-46.

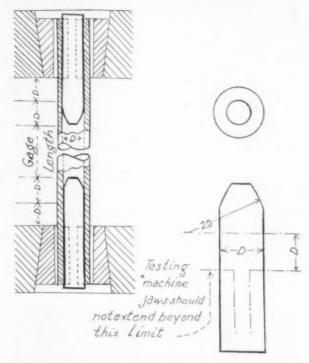


Figure 4. ASTM Standard Tube Specimen, Designation E8-46.

tin, or lead. The following testing procedure is one recommended by ASTM (5). Estimate the load corresponding to the knee of the stress-strain diagram (P, Fig. 1) and apply one-tenth of this value as the first increment of load. Note the increment of strain corresponding to this load and apply further increments of load which will produce increments of strain approximately equal to the first.

Some testing machines automatically plot the stressstrain diagram. In others, the load is read from the machine and the elongation determined by a strain gage on the specimen, extensometers, or simply measuring the distance between gage marks with calipers and a rule. The procedure to use for measuring elongation depends, of course, on the magnitude of the elongation and on the accuracy desired.

From the stress-strain diagram thus prepared, the five structural properties of the metal discussed above may be determined as indicated. It should be noted that reduction in area cannot be determined with any accuracy from the sheet specimens because of this complicated shape of the fracture surface. The tubular specimens may be used for determining this property, though measurement of the wall thickness after fracture is somewhat difficult with the thin walled specimens usually used with electroplated metals. The use of a microscope to determine the change in wall thickness is necessary in most cases.

Where only Young's modulus is to be determined a simple procedure not requiring the use of a tensile testing machine was described by *Brenner*, et al. (4). A tube of the metal is supported horizontally at both ends and loaded at the middle. The deflection of the middle of the tube is read with a Brinell microscope. The apparatus used is shown in Fig. 6. When using

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this procedure the modulus is calculated by:

where E = Young's Modulus

P = Load

L = Length between supports

= 4 PL\*

d = Deflection of center  $D_1 = O. D. of tube$  $D_2 = I. D. of tube$ 

For this formula to apply, the fiber strain must be less than 0.2%.

#### Surface Properties

#### HARDNESS

. We now proceed to a discussion of those properties of metals which are associated with the surface of the metal. The first of these is *Hardness*. Since hardness tests have been described in detail elsewhere (6, 7) they will be treated here only briefly. Hardness is usually measured by determining the amount of pene-

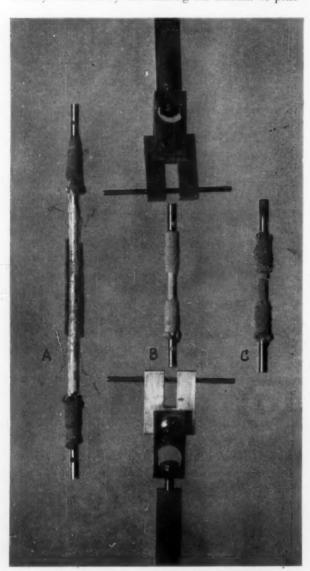


Figure 5. "Cold-welded" tubular specimens for tensile test.

A—Chromium Tube provided with wire strain gages.

B—Chromium tube prepared for tensile test, and adapters used for mounting specimen in tensile machine.

C—Specimen broken in tensile test.

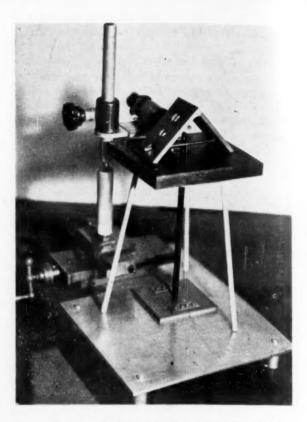


Figure 6. Apparatus for determining Young's Modulus of Elasticity.

tration of an object into the metal under the influence of a known load. Hardness may be considered a structural property as well as a surface property; but since in electroplating we are especially interested in the hardness characteristics of a surface, it is desirable to use a procedure which produces minimum penetration. This is best accomplished by using the "micro-hardness" tests. A sample is prepared by plating a smooth deposit on some basis metal. An indentation is then made with one of the standard hardness testers, and the dimensions of the indentation measured with a microscope. Instruments such as the Knoop or micro-Vickers, or others, which can be used with loads of 200 grams or less are best for measuring hardness of electroplates because a shallow penetration is obtained with the small loads. Under these conditions the sample plate need not be unreasonably thick. Using the Knoop Hardness tester with loads of 200 grams or less, reproducible hardness values may be obtained with a depth of penetration of only 0.0001 to 0.0002 inch. This indicates that the hardness of electroplates of 0.001 to 0.002 inch thick can be measured by indenting the surface without the base metal having any appreciable effect on the results. To completely eliminate any possible effect of the basis metal, hardness measurements are frequently made on a polished section of the coating with the load applied parallel to the surface of the coating. Since the Knoop indentation under the conditions described above has a width on the order of 0.0004 to 0.0008 inch, the hardness of deposits approximately 0.001 to 0.002 inch thick can also be determined in this way.

A different principle for measuring hardness is that of determining the width of a scratch on the surface produced by drawing a diamond point across the sample under controlled conditions. The instrument used for this is the Bierbaum Microcharacter. The indentation hardness and scratch hardness tests do not measure exactly the same property of a metal and therefore the results of the two tests frequently do not correlate with each other.

#### BRIGHTNESS

Two properties of great importance to the electroplater are *Reflectivity* and *Brightness*. Reflectivity is of special significance in two important applications of electroplating; the plating of reflectors, and the plating of a wide variety of military materiel. For reflectors, maximum reflectivity is required; for the military material minimum reflectivity is often desired.

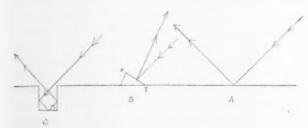


Figure 7. Diagram showing reflection of light from imperfect

There are two quantities which must be differentiated when considering reflectivity. These are total reflectance\* and specular reflectance. Total reflectivity is not a property of the surface, but rather a fundamental property which depends only on the type and arrangement of the atoms in matter. All matter strongly absorbs various frequencies of electromagnetic energy and reflects or transmits other frequencies. Those metals with minimum absorption in the visible range have high total reflectance. Specular reflectance refers, not to the total light reflected by the sample, but only to that portion of the light reflected at a specific angle from the surface of the sample. Specular reflectance depends on the total reflectance and on the surface of the material. When light impinges on a surface it is reflected at an angle equal to the angle of incidence. Therefore, on a perfectly plane surface all the light which is reflected emerges at the angle of incidence of the impinging beam (A in Fig. 7). On a surface with deep scratches (polishing marks), or on coarsely crystalline or matte surfaces, there are small planes at various angles to the surface of the sample which would reflect any light reaching them at an angle equal to the angle of incidence of the light with these individual planes. B in Fig. 7 shows how a crystal plane, X-Y, might reflect a beam of light. The reflected beam clearly emerges in a different direction from that shown in A. A scratch (C in Fig. 7) may not only change the direction of the reflected beam (depending on the angle of the

scratch), but may also cause multiple reflection, as shown, before the beam finally emerges. In the case

where R = % Specular reflectance 
$$I_r = \frac{I_r}{I_o} \times 100, \qquad \qquad \begin{array}{c} I_r = Intensity \ of \ reflected \\ I_o = Intensity \ of \ incident \\ I_o$$

Brightness is a surface property of major significance in all plating. In decorative plating it is frequently the most important property of the plate, and even in applications where the plating is done for other purposes in which appearance is ostensibly of no importance whatever, the sales appeal of bright plates has too often been confirmed to be ignored. Unfortunately, it has been very difficult to define and measure this property, although the human eye is very sensitive to it and can distinguish between very fine gradations in brightness. The most successful quantitative definition of brightness has been proposed by Egeberg and Promisel (8). They take as a criterion of brightness "the degree to which the reflection from the metal surface diverges from pure specular reflection due to the presence of light diffusely reflected." It will be noted that this definition makes brightness independent

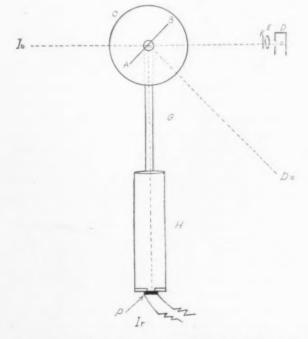


Figure 8. Schematic diagram showing principle of goniophotometer.

shown where there are three reflections, the total absorption will be almost three times the normal amount, and in this way the condition of the surface may also apparently affect the total reflectance. Since scattered or diffusely reflected light (the light emerging at angles other than the angle of incidence to the major surface of the sample) would not be focused by a simple reflector nor would contribute greatly to the luminosity of the material, it is usually not measured in determining the reflectivity of the sample. Only the specular reflectance, the light emerging at the same angle as the angle of incidence to the surface of the sample, is usually measured. It is expressed in percent by:

where R = % Specular reflectance

I = Intensity of reflected

<sup>\*</sup> Reflectance and Reflectivity will be used synonomously.

of the total reflectance of the material. They express brightness in percent by:

$$B = 100 \left( \frac{S - D_o}{S + D} \right)^a$$

where

B = Brightness

S = Specular reflection in any convenient units

D = Sum of the values of diffuse reflections taken at discreet intervals, in the same units as S, the values taken every 5°

 $D_o$  = Value of diffuse reflection at  $0^\circ$ 

\* = A constant, a convenient value for which is 8.

(When samples are very close together in brightness, increasing "a" will give numerical values with greater spread to differentiate them more easily.)

The same instrument, called a goniophotometer, is used to measure both specular reflectance and brightness. Fig. 8 is a diagrammatic sketch of a typical goniophotometer. The light source, D, a strong tungsten lamp, emits light which passes through the collimator, E, and filter, F. It is reflected from the sample, A - B, which is mounted on a rotatable table, C. The edge of the table is graduated in degrees. The light reflected from the sample goes through a focusing lens on H and falls on the photocell, P. The output of P is measured by any suitable means of measuring small currents. The receiver, H, is mounted on an arm, G, which may rotate concentrically with, but independently of, table C. To measure specular reflectance the intensity of the source, Io, is measured by swinging H to an angle of 180° with D (with the sample removed) and reading the photocell output. Ir is then measured by replacing the sample as shown, set-

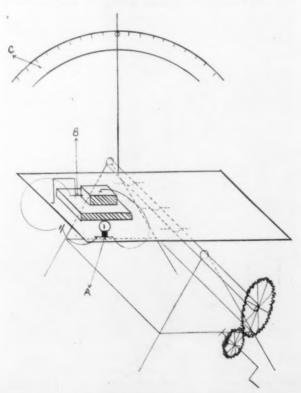


Figure 9. Apparatus used for measuring coefficient of dry friction.

ting it at 45° to D, and setting H at 45° to the sample. The photocell output is measured again. If a filter is used which corrects the light from D for the spectral sensitivity of the photocell, and for the energy distribution characteristics of "daylight," the ratio of the two readings  $\times$  100 equals percent specular reflectance.

The brightness is measured by reading the percent reflectance at intervals of 5° between the  $I_{\rm r}$  position and the  $D_{\rm o}$  position shown in fig. 8. The values obtained are plotted with intensity (% reflection) as the ordinates and degrees (taking  $D_{\rm o}$  as 0° and  $I_{\rm r}$  as  $45^{\circ}$ ) as the abscissa. The appropriate values are then substituted in the equation above. The sample used for the measurements should be a flat sheet of any convenient size. Two inch square pieces have been found to be sufficiently large for the test. The surface of the electroplate should be that in which one is interested, either as-plated, or buffed under controlled conditions. The base metal should be well polished and buffed, unless the condition of the base metal is one of the variables under investigation.

For measuring only specular reflectance, the familiar "Barrier layer" type of photocell is sufficiently sensitive. To measure brightness, however, a vacuum tube photocell and amplifier are required. Lastly, it should be mentioned that total reflectivity can be measured with the goniophotometer by scanning the sample at all angles with a fixed angle of incidence. The area under the Intensity-Angle of Reflection curve thus obtained, would be the total reflectance.

#### COEFFICIENT OF FRICTION

Another important surface property is that of the Coefficient of Friction. Applications of electroplating such as the deposition of chromium on cutting tools depend largely on the low coefficient of friction of properly prepared chromium surfaces. In addition there are many instances of plating chromium, nickel, and iron on shafts, bushings, and other bearing surfaces, especially in what is known as "industrial plating." The coefficient of dry friction is a function of the surfaces of the two objects in contact and is expressed in terms of both of them, i.e. chromium on chromium, or chromium on steel, etc. Further, the roughness of the two surfaces must be carefully controlled or the results obtained will be meaningless. The measurement is made by placing the two cleaned surfaces together, one on top of the other, on a table which can be tilted (see Fig. 9). The lower piece is held rigidly to the table. The table is then slowly tilted and the angle at which the upper piece just begins to slide is noted. The tangent of the angle of tilt is the coefficient of friction. To determine the instant of sliding, the upper block is connected with a very light lead to a flashlight bulb (A, Fig. 9) and allowed to touch the point of a small screw (B, Fig. 9). The screw is also connected through a dry cell to the flashlight bulb. The screw is then backed off one-quarter turn and the test begun. The end-point of the test is shown by the lighting of the bulb. The angle of till is read on the scale (C, Fig. 9).

Another procedure for measuring dry friction is described by *Tichvinsky* (9). It entails the pressing of a test block with known pressure against a freely rotating fly-wheel and measuring the deceleration. It should be pointed out that dry friction is frequently no indication of performance under lubricated conditions. For information on friction under lubricated conditions complicated bearing and oil testing machinery are required (10).

#### Thermal Properties

Of the thermal properties of metals, the one deserving most consideration in electroplating is the Thermal Coefficient of Linear Expansion. This is the measure of the change in length induced by changes in temperature. In those applications where an electroplated object is to be used at high temperatures, such as heat exchangers, ovens, reaction vessels, processing rolls. etc., the difference between the coefficients of expansion of the electrodeposit and the basis metal causes them to tend to assume dimensions which differ from each other. As a result, internal stresses are set up which may destroy adhesion, or crack or blister the plate. This effect is appreciable only when the temperature change is fairly large. Assuming a twofold difference in coefficient of expansion between the basis metal and the electrodeposit (the differences are usually smaller), a temperature change of 100°C. will produce stresses on the order of 10,000 to 30,000 lb./in.2 in the common metals. The actual value depends upon the values of the coefficients of expansion for the two metals and on their elastic moduli; but the figures given indicate the order of magnitude for the more usual combinations of metals. This value of stress is of about the same order of magnitude as the residual stress ordinarily found in nickel plate deposited from the Watts solution. It is clear, therefore, that temperature changes of 100°C. are not especially serious unless there are already appreciable residual stresses in the deposit, or the temperature changes are applied cyclically with short periods; in which case there may be fatigue effects. Temperature changes in excess of 100°C, however, may cause difficulties and thermal expansion effects should be given serious consideration in these cases.

The coefficient of linear expansion is expressed by:

$$a = \frac{L - L_o}{L_o T}, \quad \text{where} \quad a = \text{coefficient of expansion at} \\ \quad L_o T \quad \text{temperature } T \\ \quad L_o = L \text{ength at 0°C.} \\ \quad T = T \text{emperature (°C) of} \\ \quad \text{measurement}$$

Since the expansion does not change linearly with temperature, the coefficient is given for a specific temperature of measurement or for a narrow range of temperature. The magnitude of the coefficient of expansion is of the order of 10<sup>-6</sup> inches per degree and therefore requires very accurate length measurements. To accomplish this a tube of convenient length (approximately 1 foot) is electroplated to a thickness of at least 0.005 inch and removed from its core as de-

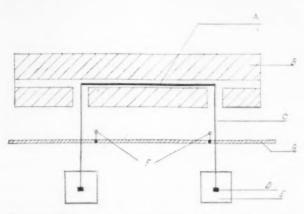


Figure 10. Schematic drawing of apparatus for measuring coefficient of thermal expansion.

scribed for the tensile test specimen. This is then placed in a furnace with accurate temperature control, and the change in length at various temperatures is measured either by an interferometer as described by Nix and McNair (11) and by Merritt (12), or with traveling microscopes as was done by Hidnert and his associates (13). The apparatus used by Hidnert is schematically illustrated in Fig. 10. The specimen tube (A) is placed in an electrically heated furnace (B) of special design. From each end of the tube is suspended a platinum wire (C), on the end of which is a weight (D) dipping into an oil bath (E). The purpose of the oil bath is to reduce vibration. Two traveling microscopes (F) are mounted on an Invar bar (G), and the position of the platinum wires, indicating the ends of the specimen, are read simultaneously with the microscopes at various temperatures.

#### Stress

In a number of previous instances the harmful effects of stress in electrodeposits was mentioned, mainly in connection with differential dimensional changes in the basis metal and coating. It is well-known, however, that many electroplates are deposited with *Internal Stress*. We may say that the stress is "plated-in." The effect of this residual stress may be very serious on adhesion, on the continuity of the deposit, and on its corrosion characteristics. It has been frequently shown that stressed deposits in a corrosive environment develop cracks even though the stresses are well below the tensile strength of the specimen (14). This phenomenon has been called "stress corrosion."

In recent years the measurement of residual stress in electroplates has developed wide interest. It has usually been measured by plating one side of a metal strip of known dimensions (4 to 6 inches long, 1 inch wide, and 0.01 to 0.02 inch thick) and known elastic modulus, in a proper fixture to provide uniform current density over the entire strip. The back of the strip is insulated with stop-off lacquer. The stress in the deposit induces a curvature of the strip which is usually measured by the displacement of one end (15), or by the camber at the center (14). The displacement is measured with a microscope in most cases.

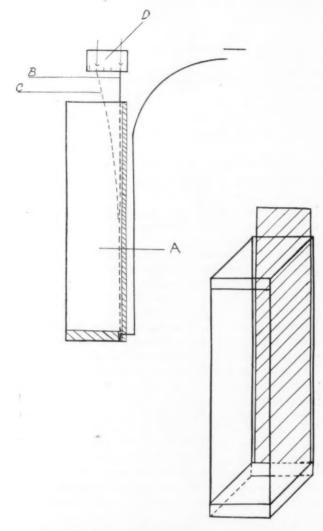


Figure 11. Apparatus for measurement of residual stress.

A new method, briefly mentioned by Brenner, et al, (4) which entails the use of a spiral instead of a straight strip, and from which displacement is read directly on a dial on the instrument, has been developed at the Bureau of Standards and will be described in detail in a forthcoming publication. A type of apparatus used for measurements with the straight strip is shown in Fig. 11. The shielding fixture (A) is made of plastic and is open in front. The strip is clamped at the bottom where electrical contact is made. B shows the position of the strip before plating; and C, after plating. D is the scale on which deflection is read with the aid of a microscope (not shown). The scale may be omitted if a microscope with a graduated eye-piece is used. Stress is calculated, approximately, from a measurement using this apparatus by:

$$S = \frac{Et^2z}{3dL^2} \quad \text{where} \quad S = Stress in lb./in.^2$$
 
$$E = Young's \text{ Modulus of strip in } lb./in.^2$$
 
$$t = Thickness \text{ of strip in inches}$$
 
$$z = Deflection \text{ of end of strip in}$$

56

inches

d = Thickness of electrodepoint in inches

L = Length of plated portion of strip

The results obtained with this formula are reasonably accurate when d/t is 0.05 or less.

#### **Electrical Resistivity**

There are two physical properties of metals which, in themselves, do not have a specific practical importance in the performance of electroplates. They are of great interest, however, because they are especially sensitive to changes in purity and structure of the deposit. These properties are Electrical Resistivity and Density. The effects of very small quantities of impurities in electrodeposits, effects either beneficial or harmful, have been one of the major problems in electroplating for many years. Work on this problem is often complicated by the inability of ordinary analytical methods to detect quantities of impurities which may be significant. The electrical resistivity, on the other hand, is extremely sensitive to impurities. and furthermore, is easily measured. It may therefore serve, under properly standardized conditions. as a standard of purity in place of composition limits of doubtful validity. Resistivity may be measured by preparing a tubular sample similar to that for the tensile test specimen and measuring the potential drop across a known length of the tube by comparing it with that across a known resistance. In the procedure described by Brenner et al. (4) the tube was placed on knife edges and the potential drop between the knife edges was measured while a current of approximately one ampere passed through the tube. The current entered and left the tube at points beyond the knife edges thus eliminating any contact resistance. The potential drop was measured with a sensitive potentiometer and compared with the potential drop across a standard 0.001 ohm resistance in series with the specimen. The resistivity is calculated by:

$$R = \frac{E}{E_{s}} \times R_{s} \times \frac{A}{L} \text{ where } R = \underset{\text{resistance})}{\text{Resistivity (or specific resistance) in ohmom.}}$$

E = Potential drop across tube in Volts

E<sub>s</sub> = Potential drop across standard resistance in volts

R<sub>s</sub> = Resistance of standard in ohms

A = Cross-sectional area of tube wall in cm.<sup>2</sup>

L = Distance between knifeedges in cm.

The readings must be taken at a specified temperature since resistivity varies with temperature. The method is illustrated in Fig. 12.

An interesting corollary of this measurement is the determination of contact resistance. Electrical switches and contacts are frequently electroplated to protect them from corrosion, as are bus-bars and rack hooks used in plating. In this application the contact re-

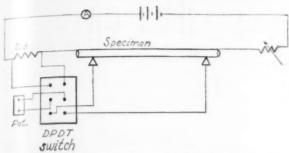


Figure 12. Electrical circuit for determination of resistivity.

sistance between the plated surfaces is of major importance. The contact resistance can be determined by a slight modification of the above procedure. After determining its specific resistance, the specimen tube is cut transversally into two parts, a small flat surface on one end of each part is prepared by filing and polishing, and the two flat surfaces are clamped in contact with each other with an insulated clamp. The resistance of this assembly is determined in the manner described above. The difference between the total resistance\* of the single tube and of the spliced tube between the knife edges (with the same current passing) is the resistance of the contact. The specific resistance of the contact in ohm-cm.² is the product of the area of the contact (in cm.²) and its resistance.

\* Total resistance, 
$$R_{\text{T}} = \frac{ER_{\text{s}}}{E_{\text{s}}}$$

#### Density

The Density of a deposit is another property of a metal which is sensitive to small changes not easily detected by other means. Density varies sharply with factors associated with the physical structure of the deposit. The presence of non-metallic inclusions, voids, micro-pores, etc., is reflected in the density of deposits. Density measurements are easily made with an ordinary chemical balance. A small specimen is cut from an electrodeposited sheet (prepared as described previously), suspended from a tared fine platinum wire and weighed in air. It is then weighed while completely immersed in a liquid of known density and the difference in weight noted. The density is calculated by:

$$D = \frac{W_A}{W_A - W_L} \times D_L \text{ where } D = Density \text{ of sample in}$$

$$g./cm.^3$$

$$W_A = Weight \text{ of sample in}$$
air in g.

W. = Weight of sample in liquid in g. D. = Density of liquid in g./cm.3

Tetrabromoethane (density = 2.96) has been recommended (4) as a suitable liquid of known density for use in this determination.

#### Summary

Thirteen of the physical properties of metals which have special interest in the field of electroplating have been discussed. This does not represent, by any means, an exhaustive treatment of the subject, but rather, it may serve as an introduction to the field as a point of departure for further work. In conclusion, it should be re-emphasized that although each of these properties has particular significance in specific applications of electroplating, the greatest value of their study lies in the advancement in the science and practice of electroplating which such fundamental information will stimulate. In recognition of the need for this information the electroplating industry, through the American Electroplaters' Society, is sponsoring a project at the National Bureau of Standards devoted to the study of the physical properties of electrodeposits. It is hoped that others will undertake work of this nature, so that before long the properties of electroplated metals will be as well established and documented as those of bulk metals.

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# The Formation of Copper Films on Non-Conductors—A Survey

By Samuel Wein, New York, N. Y.

EDITOR'S NOTE—The formation of metallic films on non-conductors is receiving ever increasing application. Although silver films are the most widely used, copper films have certain inherent advantages, notably in cost. This article details a practical method for producing copper films on non-conductors and reviews the literature on this subject.—ED.

THE formation of copper films on glass and other surfaces presents no greater difficulties than is the case with the formation of silver films. Silver films are used extensively primarily because they have better reflective qualities, higher electrical conductivity, and because the techniques for their formation have been worked out over a long period of time by the many workers identified with this ever growing art.

Copper films are intrinsicly cheaper than silver films, however, and their use has definite value in the decorative field and the electrical industry.

The technical literature on the formation of copper films is for the most part highly academic and of little practical use, and too scattered for the average chemist or technician to find without searching through a complete chemical library. In view of this, the writer presents herewith the results of a careful search of the literature, and is reviewing such literature as was not covered by him in an earlier resume.\*

Before discussing the technical literature, a practical process will be described in detail.

#### Myers Process

The present process is accredited to *Dr. Henry S. Myers*. The process is not claimed to be a radical departure from the processes as outlined in the patent and technical literature; it is however a thoroughly dependable method and inexpensive to use.

The process consists essentially of first treating the surface with a tinning solution which is made up as follows:

#### TINNING SOLUTION

Tin chloride	 180 gms.
Hydrochloric acid (con.)	 180 c.c.
Water	200 ml.

When the tin chloride has been mixed in well, allow the milky suspension to settle for half an hour, then filter the solution into a gallon bottle and dilute the filtrate to one gallon with tap water and mix well. Subsequently treat the surface with the "super-sensitizer" consisting of:

#### SENSITIZER

Gold chloride			40	*			,		i			30	grains
Water											+	50	ml.

Transfer each 10 milliliters of this 50 ml, to a separate gallon bottle and dilute to a volume of one gallon with tap water. This diluted solution is the super-sensitizer. It slowly decomposes when it stands; it is therefore suggested that only a few days supply be made up at a given time.

The copper solution is made up in two parts:

#### COPPER SOLUTION "A"

Copper sulphate				,						53	gms.
Nickel chloride							,			16	gms.
Formaldehyde .										200	ml.

These are transferred to a gallon bottle and diluted with enough tap water to make a volume of one gallon. Mix well until a perfect solution is obtained. The reducing solution is now made up of:

#### REDUCING SOLUTION "B"

Sodium	hydroxide								40	gms.
Rochelle	salts								173	gms.
	carbonate								16	gms.

These are dissolved in about 700 ml. of water and the clear solution transferred to a gallon bottle, which should have been previously coated on the inside with black Tygon paint and drained in an upside down position for 2 days. Dilute with tap water to one gallon and mix well. The bottle may also be lined with melted paraffin wax, but the solution may only keep for about a week in such a case. It is necessary to give the bottle a protective lining because the glass of the bottle contaminates the highly alkaline solution.

The procedure for forming copper films on glass is described in the following paragraphs.

#### FOR HOLLOW GLASSWARE:

1) Clean the glass thoroughly, preferably by scrubbing it with a mixture of water and a cleaning powder. Rinse with faucet water and leave the glass wet.

2) Fill the glass container with the tinning solution. Allow it to stand for about 3 minutes and pour out the liquid. This solution may be used repeatedly on fresh glass if it does not become contaminated. It deteriorates, however, and after being used for a day it should not be returned to the original bottle, but should be discarded.

3) Rinse the glass container 4 times with faucet

4) Fill the glass container with the "super-sensitizer" solution. Allow it to stand for 5 minutes. Pour out the liquid but do not rinse. The super-sensitizer may be used again on fresh glass up to about 6 to 10

<sup>\* &</sup>quot;Metallizing Non-Conductors," by Samuel Wein. Finishing Publications, Inc., New York City.

applications if it does not become contaminated with any other liquid. For best results, discard the supersensitizer after about 6 applications, or before that if it becomes contaminated.

5) Mix equal volumes of Coppering Solution "A" and Reducing Solution "B" to make the coppering solution. Fill the glass container with this mixture and allow it to stand until the proper thickness of copper apears on the glass. The copper deposition starts in 2 to 4 minutes. The copper film is of the proper thickness in about 20 to 25 minutes if the process is carried out at room temperatures. The coppering mixture of solutions "A" and "B" can be used only once and then must be discarded.

6) When the proper thickness of copper has been deposited, immediately pour out the coppering mixture and discard it. Then rinse the glass several times with faucet water. If the coppering mixture is allowed to remain in contact with the glass for an excessive time after the copper film has attained the proper thick-

ness, the copper film may blister and peel.

7) Dry the glass by hanging it upside down in a warm room. When the copper film is dry, paint it with several coats of shellac or varnish to protect it from corrosion. This coating may be done by brushing, spraying or by pouring the diluted varnish into the object and then draining it thoroughly.

#### FLAT GLASS

If flat glass is to be coppered, the following technique is recommended:

 Clean and rinse the glass as in the previous procedure.

2) Level the glass plate to a perfectly horizontal position by means of a wedge under each corner. Pour a layer of tinning solution on the glass so that it covers the entire glass surface. Allow it to stand for about 5 minutes, then pour it off.

3) Rinse the glass 4 times with faucet water.

 Pour a layer of super-sensitizer liquid on the glass. Allow it to stand for 5 minutes, then pour the

liquid off. Do not rinse the glass.

5) Mix equal volumes of Coppering Solution "A" and Reducing Solution "B" to make the coppering mixture. Pour a layer of this mixture on the glass. Allow it to remain until the proper thickness of copper appears on the glass. This should be about 20 to 25 minutes if the process is conducted at room temperatures.

6) Pour off coppering mixture and rinse as in

step 6, see above.

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7) Dry the coppered and rinsed glass by standing it in a warm place. When dry, paint it with several coats of shellac or varnish either by brush or by spray gun.

#### Literature Review

Faraday<sup>10</sup> in 1857 produced copper mirrors by heating glass plates in a mixture composed of cuprous oxide and olive oil, deposition of metal occurring when the oil was decomposed. The mirrors were poor and lacked brilliance, however.

The reduction of alkaline copper salts by the sugars such as glucose and dextrose with Rochelle salts, formaldehyde, glycol, etc., has been studied from an

academic viewpoint by Adler,<sup>1</sup> Clark,<sup>2</sup> Everett and Sheppard,<sup>9</sup> Harding and Downs,<sup>12</sup> Isbell,<sup>17</sup> Isbell and Pigman,<sup>18</sup> Isbell-Pigman and Frush,<sup>19</sup> Khadzhiev,<sup>21</sup> Kuzin,<sup>23</sup> Lundin,<sup>24</sup> Richtmyer and Hudson,<sup>32</sup> Scales,<sup>34</sup> Shaffer and Hartman,<sup>36</sup> Shaffer and Somogyi,<sup>37</sup> Somogyi,<sup>39</sup> and Todt and Scheurer,<sup>41</sup>

In 1895 Walther<sup>45</sup> drew attention to the application of phenyl hydrazine as a reducing agent in organic chemistry. Iredale and Mallen<sup>16</sup> found that hydrazine sulphate in alkaline solution would deposit copper mirrors using copper sulphate solutions.

Hydroxylamine in alkaline solution is recommended by Roldan<sup>33</sup> as a reducing agent for copper salts. Dedrick<sup>4</sup> used hydroxlyamine in silica gel for reducing

copper salts.

Hofmann and Schumpett<sup>13</sup> made a systematic study of the decomposition of copper formate, finding that it would form a copper mirror on the surface of glass. Enderli<sup>7</sup> produced copper mirrors on glass by pressing copper formate or a mixture of cupric benzoate with ammonium or hydrazine formate onto the glass surface and heating it under reducing agents. This was reproduced by Kohlschutter and Christen,<sup>22</sup> as well as by Marboe and Weyl.<sup>26</sup> By combining the decomposition of cupric formate with that of volatile organic compounds of other metals, the mirror can be modified if so desired. A dry mixture of cupric formate, calcium formate and stannous chloride, for instance, precipitates a bronze mirror.

Copper Hydride represents a rather unique method in the formation of copper mirrors on glass. The compound was first discovered by Wurtz in 1844 and can be obtained by the reduction of a copper salt solution in diluted sulphuric acid by means of hypophosphorous acid. Its chemical composition corresponds approximately to the formula CuH, but the existence of this compound has been questioned and some chemists believe that the product is more a solid solution of atomic hydrogen in metallic copper than a true chemical compound. The course which the reaction between cupric ions and hypophosphorous acid will take depends on the molecular ratio of the two ingredients. If the copper compound is in excess, it will be reduced first to cuprous ions and then to metallic copper. No hydrogen gas is liberated under these conditions. If however, the hypophosphorous acid is in excess, the reduction leads to CuH, a brown precipitate which slowly decomposes with the liberation of hydrogen.

Firth and Myers<sup>11</sup> formed copper hydride by a mixture of acidified copper sulphate with NaH<sub>2</sub>PO<sub>2</sub> in an atmosphere of CO<sub>2</sub>. This mixture passes through a series of changes, yielding unstable products which seem to be Cu<sub>2</sub>O, Cu<sub>2</sub>H<sub>2</sub> and copper phosphate. On standing, hydrogen is evolved and copper precipitated in part forming a copper mirror. At about 70°, the same solutions produce, after about 2 minutes, nearly pure Cu<sub>2</sub>H<sub>2</sub>, later Cu and H. The dry Cu<sub>2</sub>H<sub>2</sub> decomposes slowly in moist air at ordinary temperature. Sudden decomposition occurs at about 60° with the production of hydrogen and spongy copper. It appears that at ordinary temperature, the production of hydrogen precedes that of the hydride, while at 70° the order is reversed.

Marboe and Weyl.26 working with copper hydride, prepared the compound according to the method described by Vanino,42 where 75 grams of crystallized copper sulphate are dissolved in about 300 Ml. of distilled water; 310 grams of a diluted sulphuric acid (d = 1.130) and a solution of 100 grams of sodium hypophosphite in water is added and the mixture is heated to 40° to 50° C. The brown copper hydride precipitates and the reaction is complete if a filtered sample of the solution does not precipitate further amounts of CuH when heated with additional sulphuric acid. The reaction product is filtered off, washed with water and stored in a wet condition. On drying, the product loses its hydrogen more readily and occasionally its decomposition assumes explosive character.

Other workers with copper hydride are Ramachandrian, 31 Huttig, 14 Huttig and Brodkorb, 15 Wagner, 44 Vorlander and Meyer, 43 and Ethier and Haber. 8

There is one firm in the United States supplying copper hydride commercially.\*

Spring<sup>40</sup> studied the reaction of a number of metal balides with hydrogen and found that it can be used to produce films of iron as well as copper. The speed of the reaction is sufficiently slow to allow the copper chloride to volatilize and to react in the vapor phase with the hydrogen gas, if a stream of this gas is passed over a boat containing the salt.

It is evident that this reaction does not involve participation of the glass surface. The low vapor pressure of the metal causes rapid condensation of the copper atoms formed and thus precipitates the metal on the glass wall in the form of unreactive copper crystals. As a result, this reaction leads to a copper film which does not adhere to the glass and

can be easily removed.

Shelwood<sup>38</sup> adds a drop of hydrochloric acid into the hydrogen stream to form copper films from the use of copper oxide on the glass plate. A good film was likewise formed by heating cuprous chloride in the presence of hydrogen.

Sen<sup>35</sup> uses a strong solution of Rochelle salts to which there has been added formaldehyde to form copper films from a cuprous chloride solution.

Mann, Purdie and Wells<sup>25</sup> have made a study of inorganic and organic copper compounds from an academic viewpoint which deserves recording here

Williams<sup>16</sup> has developed a method for introducing copper ions into a glass surface by means of a halide vapor treatment. Briefly, this treatment consists of heating the glass to 500°C. in a cuprous chloride atmosphere for various lengths of time (15 minutes to 8 hours). The metal ions thus introduced into the glass surface by a base exchange reaction with the sodium ions of the glass may then be reduced by subjecting the glass either to cathode radiation or to the influence of a hydrogent atmosphere at relatively high temperatures (400°-500°C.). Under these conditions, if the surface concentration of cuprous ions is high enough, a copper ruby or metallic lustre is pro-

duced. However, below a certain limit of cuprous chloride exposure (1 hour at 400°C. or 1.5 minutes at 500°C.), a glass may be produced which does not show a ruby color or metallic lustre, but which nevertheless contains copper atoms. The presence of this invisible copper may be detected by the copper tartrate-formaldehyde process of physical development. The copper tartrate solutions (Fehling's solutions) are prepared and stored as two separate units, namely: Fehling's solution I 34.6 grams of CuSO<sub>4</sub> 5 H<sub>2</sub>O dissolved in 500 ml. of distilled water.

Fehling's solution II 173 grams of Rochelle salt (sodium potassium tartrate) and 65 grams of sodium hydroxide dissolved in 500 ml. of distilled water.

Equal volumes of solutions I and II are mixed just before using and for our purposes this concentrated solution was diluted in a 1:5 ratio.

A colorless reduced sample of glass (exposed to cuprous chloride for one hour at 400°C, and then reduced in a hydrogen atmosphere for 45 minutes at 500°C.) is placed in a beaker containing dilute Fehling's solution and a few drops of formaldehyde are added. The beaker is then placed in a water bath at 90°C, for 5 to 10 minutes. At the end of this time, a heavy copper deposit in the form of a mirror is visible on the glass surface.

This physical development process also was used to detect the presence of other invisible metal atoms such as silver introduced into a glass surface by means of the silver stain.

Copper acetylacetonate may be prepared according to Morgan and Moss<sup>28</sup> by shaking together a water-alcohol solution of cupric chloride, sodium acetate and acetylacetone. The pale blue powder is filtered off, washed well with water. The cupric acetylacetonate volatilizes in vacuo at about 200° C. and its vapor decomposes at higher temperatures (350-450 C.) to form adherent copper mirrors at a hot glass surface.

Dhar<sup>5</sup> finds that if an aqueous solution of cupric ammonium oxalate is exposed in a quartz glass tube to the radiation of a mercury lamp, photolysis takes place and metallic copper is formed. The ultra violet transmission of the quartz glass container and the strong absorption of the solution limit this photochemical process to the glass-liquid interface. Nevertheless no copper mirror is formed, as the copper crystalizes and deposits at the glass surface in coarse aggregates. This reaction takes place at the glass surface but without its active participation in the process.

It is known that the divalent cupric ions do not enter into base exchange with the monovalent alkali with the same ease as do silver ions. Furthermore, cupric ions present in the glass are not reduced to elemental copper with the same ease as silver ions. Consequently, copper mirrors cannot be obtained from cupric compounds by a reaction analogous to the silvering process, but require a modification of the glass surface, e. g., an activation with metallic silver, copper or gold in order to make it a catalyst.

(Concluded on page 69)

<sup>\*</sup> Metal Hydrides, Inc., Beverly, Mass.

## Phosphatization of Metallic Surfaces

By Michael A. Streicher, Dept. of Metallurgy, Lehigh Univ.

#### Introduction

EVEN though the first patent on phosphate rust protection was taken out by Ross in 1869, 60, 61 Thomas W. Coslett of Birmingham, England, was the first to make the phosphatization of iron and steel industrially applicable. In a series of patents beginning in 1906, Coslett 62 described his process. He suggested that the free acid content should be kept as low as possible, that the coating should be oiled or otherwise treated to increase further the corrosion resistance, that an electric current may be used to accelerate the reaction, and that addition agents (borates) may be used to reduce the time required for phosphatization. Coslett may be considered the originator of industrial phosphatization, and his work is the basis of phosphatization as it is known today.

When a metallic surface is exposed to a corrosive environment, solution of the metal takes place, resulting in corrosion products which, in turn, have a decisive influence on the subsequent course of the disintegration process. If the corrosion products are soluble or if they are only slightly soluble and precipitate near the metal surface, thereby forming a non-adherent, scale-like coating, the attack continues and finally results in complete disintegration of the metal. However, if the corrosion products precipitate on the surface of the metal and form an insoluble. adherent film, further attack is retarded or stopped. The rusting of iron produces a non-adherent scale, while the ever-present oxide film on aluminum gives a considerable degree of protection to this metal toward a number of otherwise corrosive environ-

This naturally occurring formation of an insoluble protective film has been imitated under controlled conditions. A thicker, even more protective oxide film, is produced on aluminum by chemical or electrochemical treatment, and iron and steel may be given an adherent oxide coating by proper treatment in various salt baths. Phosphate coatings are produced in a similar manner. On immersion in the phosphatizing solution, the metal goes into solution and causes precipitation of a coat of fine crystals of secondary and tertiary phosphates.b The formation of these surface conversion coatings may be considered a form of controlled "corrosion".1 During the formation of such coatings, the metal at first corrodes (dissolves). The dissolved metal then combines with one or more constituents of the treating solution and, together with other constituents of the bath which have become insoluble because of the shift in equilibrium caused by the dissolving metal, precipitates at the surface in

the form of a coating which may inhibit further disintegration.

The corrosion protection given to metals by such coatings is usually limited. In order to increase their protective value, the coated surfaces are given a sealing treatment or are used as a base for additional coatings of oil, paint, shellac, lacquer, stains, and other organic finishes. Excellent absorption of these finishes in the pores of surface conversion coatings, especially the phosphate type, creates an efficient bond between the metallic surface and the outer finish. The most frequently phosphatized metals are iron and steel, c zinc, cadmium, and aluminum. Phosphate coatings may be used (1) to inhibit corrosion; (2) to reduce wear; (3) as a lubricant; (4) a base for an additional finish; or (5) a lubricant carrier during extruding and drawing operations.

#### Process

Metals are given phosphate coatings by subjecting them to a dilute, aqueous solution containing one or more primary phosphates of zinc, iron, or manganese, phosphoric acid, and various types of accelerators. Coatings are produced either by immersion in this solution, or by spraying, for periods varying from a few seconds to one hour. The time required for treatment depends on the thickness of coating desired, the temperature of the solution, the accelerating methods, and the method of application of the solution used. The properties of the coats are determined not only by the composition of the solution but also by the method of cleaning used in preparation for phosphatization. Cleaning is sometimes followed by a pre-treatment in order to activate the surface for phosphatization. After coating and rinsing the surface, it may then be given a passivating or sealing treatment in a dilute chromic acid or chromate solution to increase its corrosion resistance. The steps in the complete process are (1) cleaning, (2) rinsing, (3) pre-treating, (4) phosphatizing, (5) rinsing, (6) sealing, (7) drying. Either the third or the sixth step, or both, may be omitted, depending on the requirements. These various treatments and their effects on the phosphate coatings will now be described in more detail.

Because the effects of various cleaning methods and activating treatments are revealed only when the prepared surfaces have been exposed to the phosphatizing solution, the action of the coating bath will be discussed first. Phosphatization has, until recently, been

<sup>&</sup>lt;sup>a</sup> The presence of moisture is assumed.

<sup>&</sup>lt;sup>b</sup> Primary phosphates contain H<sub>2</sub>PO<sub>4</sub>', secondary HPO<sub>4</sub>", and tertiary PO<sub>4</sub>"'.

<sup>·</sup> This does not include high alloy steels.

carried out in solutions at a temperature just below the boiling point (98°C.) to avoid excessive evaporation and, at the same time, to produce coatings in the shortest possible time. Treatment at this temperature does not change the mechanical properties of the metals most frequently phosphatized. Since 1940, low temperature (25-55°C.) solutions have been in use.

#### Principles of Phosphatization

The phosphatizing bath, consisting of phosphoric acid, one or more primary metal phosphates, and accelerators diluted with water,<sup>d</sup> reaches an equilibrium whose position depends on the temperature of the solution and the relative concentration of chemicals present. The primary phosphates of iron, zinc, or manganese dissociate to form secondary and tertiary phosphates. Using zinc as an example:

$$3 \operatorname{Zn}(\operatorname{H_2PO_4})_2 \rightleftharpoons 3 \operatorname{Zn}(\operatorname{HPO_4}) + 3 \operatorname{H_3PO_4}$$
  
 $3 \operatorname{ZnHPO_4} \rightleftharpoons \operatorname{Zn_3(PO_4)}_2 + \operatorname{H_3PO_4}$ 

$$3 \operatorname{Zn}(H_2PO_4)_2 \rightleftharpoons \operatorname{Zn}_3(PO_4)_2 + 4 \operatorname{H}_3PO_4 (A)$$

With the exception of secondary zinc phosphate, the salts thus formed are only slightly soluble<sup>2</sup> and, in the absence of free phosphoric acid, are precipitated as sludge by any factor which causes increased dissociation, such as a rise in temperature or a decrease in concentration. For this reason free phosphoric acid must be present to drive the reaction to the left and prevent precipitation of phosphatizing chemicals as sludge. When ferrous metals are immersed in the phosphatizing solution, hydrogen ions supplied by free phosphoric acid cause an etching attack on the metallic surface. Iron dissolves and hydrogen ions are discharged, probably by the action of local cells composed of minute anodic and cathodic areas.

$$2H^+ + 2e \rightarrow H_2$$
 (B)

The decrease in hydrogen ion concentration in the layer of solution next to the metal surface shifts the equilibrium of reaction (A) to the right. The solubility products of the secondary and tertiary phosphates are exceeded, and these salts precipitate from the solution, nucleated by points in the metal surface, and grow to form the phosphate coating. During this process the original state of equilibrium is at least partially restored by the phosphoric acid which is formed.

#### Acid Ratio

To indicate the relative concentrations of metal phosphates and free acid, the acid ratio is used. This ratio is found by titrating equal volumes of soloution with standard hydroxide solution, using phenolphthalein indicator to determine "total acid" and methyl orange indicator to determine "free acid." The volume of alkali used for the phonolphthalein titration divided by the volume used for the methyl orange titration is known as the acid ratio. When 1/10 N

alkali is used for the "total acid" titration, the number of milliliters used to titrate ten milliliters of phosphatizing solution is known as the "point strength." a measure of the concentration of phosphatizing chemicals. The "free acid" titration (using bromphenol blue) is a measure of the free phosphoric acid in the bath, and "total acid" is proportional to the concentration of both free acid and primary metal phosphates.

The acid ratio must be kept within certain limits. The concentration of free phosphoric acid should be just sufficient to cause etching of the surface, which, in turn, disturbs the primary metal phosphate equilibrium in the solution near the surface. An excessive concentration of free acid (low acid ratio) results in prolonged etching because precipitation of phosphate crystals is delayed. In this case, the time required for the formation of a coating is increased, and the protective value of the coating is reduced because of a decrease in the tertiary salt content of the coating? If the acid ratio is too high (low concentration of free acid), the protective value of the coating is also reduced. This is probably because of insufficient etching attack before precipitation of the coating begins. Still higher values of acid ratio extend the precipitation of phosphates taking place in the layer of solution adjacent to the metal to the entire solution, and a large quantity of phosphatizing chemicals is lost as sludge.

In a zinc phosphate bath containing an accelerator, the acid ratio may, by the addition of phosphoric acid, be decreased from a value just sufficient to prevent sludge formation on heating. The coatings thus produced vary from light-colored, finely crystalline coatings to darker and coarser coatings, until finally an almost black coat is produced, consisting of coarse, sparkling crystals. This latter structure, resulting from excessive acidity, is known as "sparkle." The light-colored, gray coatings consist primarily of zinc phosphates, while the dark, coarse coatings contain

<sup>&</sup>lt;sup>1</sup> Macchia<sup>3</sup> has suggested the use of bromphenol blue in place of methyl orange for better results in determining the end point.

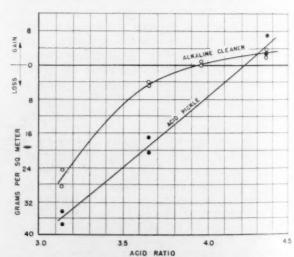


Fig. 1. The effect of acid ratio and method of cleaning on the change in weight of an object during phosphatization. Low-carbon steel sheet was used (67).

<sup>&</sup>lt;sup>d</sup> Usually a concentrated liquor of these chemicals is added to water to make a phosphatizing solution.

<sup>&</sup>lt;sup>c</sup> Ferrous metals are the most frequently phosphatized metals and will be used as an example throughout this paper.

increasing quantities of iron phosphates, which are produced by the strong etching action of the more acid solutions. The corrosion resistance is reduced as the structure coarsens and as the iron phosphate content of the coating is increased.

The change in weight of an object during phosphatization depends on the acid ratio. It was found that as the acid ratio is decreased from a certain value (free acid concentration increased), the loss in weight increases. Acid ratios above this certain value cause a progressive increase in weight. Figure I illustrates a typical condition. Two opposing factors determine whether there is a loss or gain in weight during phosphatization. Weight is lost as iron dissolves, while the precipitation of phosphates adds to the weight of the object.

The optimum acid ratio range varies with the bath composition and the type of metal to be treated. Since the dissociation constants of various metal phosphates differ<sup>2</sup>, the amount of free acid required to keep them in solution will depend on the metal phosphate used.

The absolute concentration of phosphatizing chemicals in the solution is also a decisive factor in determining the quality of the coatings produced. Dilution or concentration of the solution does not change the acid ratio, but it is reflected in the point strength of the bath. The attack of the free acid on the metallic surface shifts the equilibrium, and precipitation of secondary and tertiary phosphates takes place. However, this shift takes place so rapidly at low absolute concentrations that precipitation occurs not only on the metal surface but throughout the solution. Excessive absolute concentrations of chemicals vigorously etch the metal being coated, and, as a result of the high concentration of acid, the equilibrium shift is delayed. The acid formed when precipitation takes place tends to re-establish equilibrium, and it may dissolve the coating. In the cases of both low and high absolute concentrations, treatment time is prolonged, and large quantities of sludge are formed. The corrosion resistance of coatings formed in such solutions is also adversely affected. As the absolute concentration is increased from a low to an optimum and then to a high value, the coatings vary in appearance from thin, dark, and uneven at low values to finely crystalline and smooth at optimum values, and to black and coarse at high concentrations.

#### Accelerators

During the etching action of the free acid, hydrogen is liberated. Bubbles of gas blanket the surface being coated and retard further attack of the solution on the metal. To reduce formation of hydrogen gas and remove the film of hydrogen from the surface, an oxidizing agent is added to the bath. The oxidizing agent, or accelerator, combines with most of the hydrogen, while it is in the atomic state, to form water. For this purpose, nitrates, nitrites, chlorates, and hydrogen peroxide are added to the solution. 46. h It was

found<sup>2</sup> that the volume of gases evolved from a bath containing a nitrate accelerator was only 3% of the volume evolved from a bath without accelerator while comparable coatings were being produced. In the case of the accelerated bath, the gases consisted of only 15% hydrogen, the remainder being nitrogen formed in the reduction of the nitrate. The gas evolved in the bath without accelerator was mostly hydrogen.

Care is taken to use oxidants whose cations do not contaminate the solution. This may be accomplished by using accelerators whose cations enter the coating (Zn, Mn). The use of accelerators reduces the time required to form a coating from one or two hours to ten minutes or less. Addition of increasing concentrations of oxidant progressively reduces the amount of gas evolution and the time required for the formation of a good coating. After an optimum concentration is reached, streaky, coarse, and uneven coats are produced. If more phosphoric acid is added, the coatings again become fine-grained and smooth. Thus, within limits, the results of excessive concentrations of oxidants can be counteracted by increasing the free acid concentration. This effect confirms Machu's 1 observation that the surface becomes passive when excessive amounts of oxidants are used. By adding more acid, this passivity may be overcome.

The coating process may also be accelerated by increasing the rate of dissolution of iron. Small quantities of copper, added in the form of soluble salts, precipitate on the surface of the metal being coated and form the cathodes of numerous, minute electrochemical cells. Since copper is deposited in the metallic state during the formation of the coating, the finished surface contains local cells, which reduce its corrosion resistance. Despite this, the rapid action of the solution makes this type of coating especially suitable for paint-bonding.

#### Low Temperature Baths

An auxiliary accelerator is often added to a bath already containing an oxidant when the solution is to be used at lower temperatures, 25 to 55°C. A zinc phosphate solution containing sodium nitrite and fluoride is described by Földes. Dissociation of sodium fluoride to the acid fluoride, (NaHF<sub>2</sub>), takes place, thus maintaining a constant pH. In the operation of low temperature baths, the pH of the solution must

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In solutions having a large absolute concentration, considerable quantities of iron are dissolved, which are oxidized to insoluble ferric phosphates by accelerators.

b Organic compounds such as picric acid, nitroaniline, hydroxylamine, and quinone are sometimes added, usually to solutions already containing an inorganic accelerator. A possible mechanism for the accelerating effect of this type of compound is described under "Theoretical Discussion". An alternating electric current has also been applied to objects being coated to improve the quality of the coatings and to reduce the time required for their formation.

Still other methods of accelerating the action of phosphatizing baths will be discussed in connection with activation pre-treatments and methods of applying the solution to the surface.

be kept within definite limits for successful operation. From the previous discussion on the effect of various concentrations of free acid in the phosphatizing bath, it can be seen that the decrease in the rate of coating formation at lower temperatures cannot be counteracted by increasing the free acid concentration. Only enough free acid to cause etching and dissolution of iron is permissible. Etching then upsets the existing equilibrium condition in the solution near the surface and results in precipitation of phosphates. Schuster and Krause have shown that at 25°C. the amount of free acid required to keep tertiary zinc phosphate in solution is only 37% of the amount necessary at 98°C. Therefore, the amount of free acid necessary in a low temperature bath is actually less than that required for a solution operated at near-boiling temperature.

In addition to temperature, the hydrogen ion concentration also depends on the absolute concentration of chemicals (point strength), the metal phosphate, and the type and concentration of accelerators used. Various fluorine compounds aid in maintaining the pH constant within a small range while the bath is being exhausted by continued use. Thus, the operating conditions, acid ratio, point strength, and concentrations of accelerators for low temperature baths are different from those operated at near-boiling temperatures. However, the principles which determine the formation of the coatings remain the same.

Auxiliary accelerators are also added to solutions used to form phosphate coatings on aluminum and its alloys at about 80°C. Zinc fluoborate is added to a zinc phosphate solution containing a nitrate accelerator. The fluoborate is said to activate the surface prior to the formation of the coating. When the hydrogen ion concentration is kept within the optimum range, the etching attack of the solution on the surface is most effective. As above, the activating mechanism of the fluorine compound probably consists of maintaining the pH within this range.

A comparison of the action of several kinds of phosphatizing solutions reveals that accelerators not only greatly reduce the time required to produce a coating but also effect the composition and operating characteristics of the solution to which they are added. Without accelerators the composition of the solution changes while in use, and the rate of sludge formation increases continuously along with the consumption of phosphatizing chemicals. Addition of a nitrate accelerator considerably reduces the quantity of sludge formed per unit area of surface coated.11 With the exception of solutions in which phosphate coatings are produced to reduce wear (manganese phosphate solutions), the most frequently used solutions contain zinc phosphates and an oxidizing agent. 12, 13, 14, k Modifications of this composition for individual requirements are obtained by varying the acid ratio and by the addition of auxiliary accelerators.

The oxidizing compounds convert soluble, ferrous phosphates, formed when iron dissolves, to insoluble

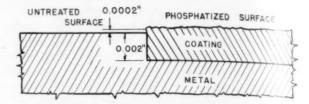


Fig. 2. Schematic diagram showing the change in dimension of an object during phosphatization in relation to the actual thickness of a medium-heavy coating (67).

ferric phosphates, which precipitate as sludge. In zinc baths containing a nitrate accelerator, the iron content of the solution rapidly increases from zero to a constant value as the solution is used.11 In this way a large accumulation of iron is avoided, and the iron phosphate content of the coating is kept constant at a low value. These coatings, consisting primarily of tertiary zinc phosphate with small amounts of secondary and tertiary iron phosphates, have uniform corrosion resistance. When a solution of this kind is first used, it contains only zinc phosphates and is free of sludge. Until some sludge is produced, the coatings are very thin and non-uniform. As soon as a certain quantity of iron has dissolved, sludge is formed, and the solution becomes cloudy. The solution is now aged and produces fine, uniform coatings. This aging effect can be produced by adding iron phosphate liquor to the solution or by treating cleaned iron scrap in it before it is used. If the chemical constituents of the solution are not used up at the same rate during coating operations, the composition of the replenishing chemicals must be adjusted to make up for this.

Formation of phosphate coatings may be largely inhibited by the presence in the solution of quantities of arsenic as low as 0.005%. Arsenic deposits on the surface of iron in the form of a thin rose-gray film. When found in phosphatizing solutions, arsenic is introduced as an impurity in the phosphoric acid and may be removed by exposing scrap metal to the solution. All arsenic deposits on this metal and the

bath may then be used effectively.1

Regardless of the type of solution used or the method of application on withdrawal, the coated surfaces must be thoroughly rinsed to remove all traces of phosphatizing solution and any particles of sludge which may have settled on the surface during coating.

#### Industrial Phosphatization

The phosphatization process has been applied on a large scale industrially. The oldest apparatus consists of a series of heated tanks connected by an overhead trolley to facilitate movement of the objects being treated. This is still in use where batch processes are used, e.g., for the five- or ten-minute treatments required to produce phosphate coatings for wear and corrosion resistance, and for small-scale applications of phosphatization. For each operation, beginning with cleaning and ending with rinsing or

 $<sup>^{\</sup>rm k}$  An example composition of the liquor which is added to water (1:50) is, in grams per liter:  $P_2O_5-131,$  Zn-200,  $NO_3-300.^{13}$ 

<sup>&</sup>lt;sup>1</sup>This effect of arsenic is used to advantage in sulfuric acid solutions in which arsenic is used as an inhibitor.<sup>59</sup>

sealing treatments, there is a separate tank. Use of phosphatization on assembly lines was made possible by the development of a continuous spray method to produce paint-bonding coatings. 15, 16 The articles to he coated, such as automobile fenders, doors, and other large parts, move through a series of spraying chambers in which they are cleaned, rinsed, phosphatized, rinsed again, and dried.

Another process10 used for treating sheet metal. (steel, galvanized steel, and aluminum) consists of feeding the sheets through rubber-covered rolls to a chain conveyor, which carries them through a tank containing the phosphatizing solution. On emerging from the solution, they are conducted through another set of resilient rolls, which remove excess solution and reduce drag-out losses. Treatment in the rinsing and sealing solutions is followed by passage through rolls for the same reasons. Coatings are also formed by feeding the phosphatizing solution between the metal and roll surfaces.17 Passage of the sheets through resilient rolls before or during phosphating reduces the time required for the formation of a coating.18 The action of the rolls and the sprays on the surface of the metal is probably similar to the wiping effect, which will be discussed later.

#### Preparation of the Surface

The composition of the phosphatizing bath, together with the method of cleaning and pre-treatment used, determines the character and properties of the coating. Using a certain bath composition, a variety of phosphate coatings differing in structure may be obtained. The structure of the coating is largely determined by the relative rates of nucleation and crystal growth, which, in turn, are affected by the condition of the surface. The surface to be coated must be thoroughly cleaned to remove all traces of grease, rust, and scale. This may be done by vapor or solvent degreasing, acid and alkali cleaners, or pickling, or by mechanical methods, such as sand blasting, grinding, polishing, brushing, and wiping. To avoid contamination of the treating solution, all chemical cleaning must be followed by thorough rinsing. Whenever possible, strong chemical action during cleaning should be avoided. Acid pickling and strong alkali treatment result in rapid consumption of phosphatizing chemicals and a coarse coating having the same appearance (sparkle) as the type of coating produced in solutions containing excessive concentrations of

Weight changes during phosphatization are partly determined by the method of cleaning used, acid treatment giving greater losses or gains in weight than treatment in alkaline cleaners. This is also illustrated by the two curves in Figure I. The best coatings are obtained when the surfaces are mechanically treated or are wiped after chemical treatment.

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#### Wiping Effect

When, after cleaning, the surface is wiped with a brush, a cloth, or the hand, a remarkably fine and smooth coating is produced. This phenomenon is known as the "wiping effect" and has been observed by a number of investigators. 19, 20 Several attempts have been made to produce this wiping action by exposing the cleaned and rinsed objects to activating solutions before treatment by the coating solution. Romig19 introduced a pre-dip for this purpose containing oxalic acid and another whose pH is kept between 5 and 6.21 An improvement on these activating solutions was discovered by Jernstedt, 20, 22 who introduced a pre-dip solution containing 1 to 2% disodium phosphate activated with small quantities of titanium ions (0.005-0.05%). Exposing the face to this pre-dip reduced the time required to form a coating in the phosphatizing solution to one-third of the original, and the corrosion resistance of the coating was improved.

The activity of this solution is attributed by Jernstedt to the adsorption of a film containing the phosphate ion on the metal surface prior to treatment in the coating solution. Only when titanium is in the colloidal state does the solution activate the surface.

While the results of various pre-dips approach the effect produced by mechanical wiping, the respective mechanisms by which the finely crystalline and smooth coatings are produced in each case are probably not the same. The dissolution of metals, which often is a part of chemical cleaning, is accompanied by the formation of a film of precipitate which cannot be removed even by vigorous rinsing but which can readily be eliminated by light mechanical wiping. During wiping of the surface, this film, an inhibitor in the phosphatization process, is removed, thus providing better access of the solution to the surface. The film may be a colloidal metal hydroxide and may be invisible. The mechanism of activation by predips has not been investigated.

#### Properties and Uses of Phosphate Coatings

Except when phosphate coatings are to be used for wear resistance, the most desirable coatings are those having the finest grain structure and the smoothest texture obtainable. Coatings vary in thickness from mere flash-layers of undeveloped crystals applied in a few seconds for paint bonding, to thick blankets of crystals used to increase corrosion resistance or to reduce wear. To form the latter requires five or ten minutes of exposure to the phosphatizing solution. By varying the composition (accelerators), operating conditions (acid ratio and point strength), and the method of application, all of these types of coatings may be produced.

The composition and structure, and, hence, the properties, of coatings produced in low temperature solutions are equal to those formed in solutions operating at near-boiling temperatures. However, the treatment time required with low temperature solutions to produce equivalent properties is somewhat. longer.9 Because the coating action depends only on contact between the solution and the metallic surface and is not dependent on an electric current, objects of irregular contour are coated as efficiently as flat

Coating a metallic surface with a layer of fine crystals of phosphates creates a new surface having

completely different properties. The surface becomes largely non-metallic, electrically non-conducting, enormously enlarged in specific area, and more plastic, porous and adsorptive. The metal itself remains unchanged in hardness, tensile strength, elasticity, and magnetic properties.<sup>m</sup> For a medium heavy coating, the dimensional change on phosphatization is an increase of about 0.0005 cm. (or about 0.0002 in.). This is not, however, the actual thickness of the coating. During phosphatization the metal first dissolves before the coating builds up. Therefore, the thickness of the layer of crystals is greater than a measurement of change in dimension indicates. Cross-sectioning and optical examination of a coated sheet reveals that the actual thickness of a medium heavy coating is about 0.005 cm. (or about 0.002 in.) See Figure II.

Phosphate coatings formed in zinc solutions may be heated to about 300° C. without any visible change taking place. When heated above this temperature, the coating changes in color from gray-black to dull black, velvety, dark red, and dark blue. At about 400° C., the coat begins to peel in flakes leaving a silvery, metallic surface.

For increased corrosion resistance, objects are given coatings of medium thickness, as described above. To increase this resistance further, the surfaces, after rinsing, are exposed to a sealing solution which contains chromate or dichromate compounds.<sup>23</sup> Chromates are powerful inhibitors for iron.<sup>24</sup> Their protective action, however, is dependent on a continuous supply of chromates. For this reason the protective value of chromate sealing treatments on phosphate coatings is only temporary, and further protection is required.<sup>6</sup> Objects, usually tools and machine parts, treated in this way are, therefore, dipped in oil to give a more permanent type of protection. Black coatings are obtained by adding coloring matter to oil.

The large specific surface and porosity of even thin phosphate coatings make them excellent bonding agents for paints and other finishes used on metals. By increasing the surface area, adhesion, a result of intermolecular forces of the kind responsible for solution, wetting, and adsorption, is enhanced, while the irregularities of the crystalline coatings, pores and cavities increase the mechanical adhesion. Yery thin coatings formed in a few seconds of spraying suffice to produce these effects. When a finish, bonded to the metal by a phosphate coating, is scratched down to the metal itself and exposed to a corrosive environ-

ment, the destructive attack is largely confined to the scratch. There is little peeling caused by progressive attack under the finish.

Because zinc surfaces react with paints and other organic coatings, these finishes dry out and flake off. This makes the painting of zinc parts (die-castings) and galvanized steel difficult. By applying a phosphate coating on such surfaces, peeling and flaking of the finish are avoided.58 The combination of a zinc coating on steel, which gives both mechanical and electrochemical protection, with a paint finish bonded to the zinc surface by a phosphate coating, provides thorough corrosion protection for most severe exposures, such as encountered in roof-drainage systems and washing machines. Phosphate coatings have also been recommended as bonding agents for coatings formed by metal spraying.27 The shortage of tin for the canning industry in various parts of the world has led to the widespread use of lacquered phosphate coatings as a substitute.13, 28, 29

A more recent use of phosphate coatings takes advantage of their ability to act as a lubricant and to retain other lubricants in drawing and forming operations. Wüstefeld30 has found that a phosphated rod drawn dry shows plastic shaping of the crystals in the coating. When the phosphate coating is impregnated with a liquid soap solution, the plasticity of the phosphate layer is increased as the coating is crushed and ground with the lubricant to form a plastic mass during drawing. In this way the phosphate coating, in combination with a lubricant, reduces friction and power consumption and increases die life in drawing operations. 12,31 The use of phosphate coatings as an aid in drawing has become standard practice. It is being used extensively in seamless steel tube mills and other deep drawing operations.32 Cold extrusion of steels has been made possible by the use of special dies and phosphate coatings as a lubricant.33 This process, by which tubular, cylindrical and other symmetrical forms can be produced, eliminates several annealing, pickling, and machining operations.60

As has been mentioned previously, thick, relatively coarse, manganese phosphate coatings are used to reduce wear. Such coatings have been found to increase the scuffing load on gears to more than twice that for untreated gears. The running-in properties of piston rings are improved by a graphite-impregnated phosphate layer. The phosphate coatings are used to reduce wear, metal-to-metal contact is prevented, and, in addition, the coating may act as a reservoir for oil. After the coating has worn off, a rough surface remains, which continues to act as a reservoir for oil and, at the same time, provides an escape for wear particles. The surface representation of the same time, provides an escape for wear particles.

The electrical insulating properties of phosphate coatings are used to insulate magnetic sheets.<sup>64</sup>

m In the case of ferrous alloys the properties of the coatings produced on them are determined by the surface pre-treatment (cleaning) rather than by alloying elements. <sup>65</sup>

<sup>&</sup>lt;sup>n</sup> This value is in agreement with those of Machu, 0.002 cm., and Gutman, 0.0008 cm.<sup>4</sup>

<sup>°</sup> Of the many tests<sup>25</sup> that have been applied to phosphate coatings, alternate immersion, humidity, weight loss on exposure to corroding media, mechanical bending and scraping, and salt spray, the latter is the only widely used test. It has been jound to be the most sensitive, and, in general, the results of the various other corrosion tests are found to be in agreement with the results obtained with it.<sup>11,28</sup>

P Krause<sup>63</sup> found that a manganese phosphate solution gives the best results in the case of relatively pure zinc surfaces, while a zinc phosphate solution is to be preferred for zinc alloys containing aluminum.

alt has been found that finely porous, medium coarse crystals rather than very coarse or fine crystals give best results.



F.g. 3. Phosphate crystals on pure iron. Mag. 600X. These crystals were produced during the initial attack of the solution after a few seconds of immersion.

#### Theoretical Discussion

The dissolution of metals in electrolytes may be considered a greatly accelerated form of corrosion. Almost all corrosion takes place in the presence of water (moisture), which usually has dissolved in it gases or salts which increase its conductivity. By substituting solutions of relatively concentrated acids, bases, and salts for this ever-present moisture, reaction rates, diffusion, and effects related to local cell action are greatly accelerated. A large and varied amount of experimental evidence r indicates that the dissolution of metals is often governed by an electrochemical mechanism. The results of these experiments can be explained only by the existence of local cells consisting of minute anodes and cathodes at the metallic surfaces.

Akimow and Paleolog<sup>43</sup> have shown by indicator tests that a phosphatized surface contains electrochemically inert areas (relatively thick spots), cathode areas (thin spots permeable to electrons), and anode areas (pores and cracks). During phosphatization metals are first dissolved (corroded) by local cell action, and then, as a result, they initiate a reaction in the corroding medium which stifles further disintegration by the formation of a precipitate at the surface. Phosphatization is, therefore, an electrochemical heterogeneous, topochemical process.

The underlying electrochemical, local-cell mechanism is modified by topochemical factors and by the polarizing and depolarizing effects of some accelerators. When potential measurements are made during phosphatization, it is found<sup>44</sup> that the solution potential of the metal being coated at first drops very rapidly to more noble values and then continues to drop at a considerably slower rate. Machu<sup>4</sup> finds that this solution potential curve conforms with Müller's

Law of auto-passivation. According to this law, the above-described behavior of the solution potential is explained by the reduction of the total anodic area by a precipitate (phosphate coating) and a consequent increase in the current density of the remaining anodic points. This current density finally increases to a value at which the reactions of the passive state are possible.

The theory of phosphatization proposed by Machut states that phosphate coatings can precipitate only at cathodic areas. Any factor which increases the ratio of cathode area to anode area will accelerate phesphatization. Machu uses this theory to explain the action of all accelerating methods. The above-mentioned cathode-anode-area ratio is increased by oxidizing agents because they are assumed to passivate anodic points. Reducing agents, such as sulfurous acid and sodium bisulfite, are thought to cause cathodic polarization, while copper, precipitated on the surface, greatly increases the cathodic area. Organic nitrogent compounds, picric acid, nitroaniline, hydroxylamine, quinone, and others, are considered to polarize the surface cathodically.

The previously proposed mechanism of acceleration of oxidizing agents by depolarization, removal of hydrogen in the atomic state, 2, 45, 46 is rejected by this theory. However, since phosphatization depends directly on the shift in equilibrium caused by the dissolution of the metal, it seems probable that the rate of coating formation is influenced by the rate at which the metal dissolves. This dissolution is governed by local cell action during which the metal enters the solution at the anodes and hydrogen is liberated at the cathodes. An oxidant rapidly removes hydrogen (depolarizes) at the cathodes, thereby accelerating the anodic reaction and, at the same time, reducing hydrogen bubbling, thereby permitting better contact of the solution with the surface.

dissolving surface, greatly increase the number of local cells. This accelerates the dissolution of the metal being coated and provides a large number of points of nucleation, thus giving a fine-grained coating.' Mechanical wiping has a similar effect of increasing the number of points of nucleation. Both the "wiping effect" and the addition of accelerators to the solution actually decrease the total amount of metal which dissolves during the coating process.<sup>7, 11</sup> Acceleration may, therefore, be considered as consisting of two effects—more efficient utilization of the dissolved metal by an increased number of points of

Copper and other metals, when deposited on the

nucleation and an increased rate of dissolution of the

metal being coated. There may thus be several mech-

anisms by which various accelerating methods and

agents increase the rate of coating formation. Indus-

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This includes the ferroxyl test<sup>35</sup> on iron and steel and other indicator tests for non-ferrous metals, <sup>36, 37, 38</sup> the effect of impurities on the solution rates of metals in electrolytes, the "difference effect", <sup>39, 40</sup> and the phenomenon of cathodic protection. <sup>41, 42</sup>

<sup>&</sup>lt;sup>6</sup> This increase in the rate of dissolution of metals by impurities which are cathodic to the metal has been confirmed by a number of investigators. 47, 48, 49, 50, 51, 52

The theory of Machu<sup>4</sup> admits of only one type of acceleration mechanism, that of increasing the number of points of nucleation by increasing the cathodeanode ratio.

trial phosphatizing solutions usually contain combinations of accelerators, which are used to supplement one another.

The heterogeneous, topochemical character of corrosion reactions has led several investigators to a comparison with other reactions of this type, those of heterogeneous catalysis. As previously described, phosphatization may be considered a form of controlled corrosion and may, therefore, be included in this comparison. Also, the beneficial effect of minute quantities of titanium ions (0.001%) in pre-dip solutions and the detrimental effect of small amounts of arsenic (0.005%) in phosphatizing solutions suggest a catalytic mechanism for the action of these substances.

Investigations on adsorption in connection with studies of solid catalysis resulted in the discovery that the surface of such catalysts is variable and contains active centers. 58,54 Pietsch and Josephy 55 consider these active centers to be active lines, crystal edges, crystal boundaries, and imperfections in the crystal. They further point out that edges are preferred centers of activity as nuclei of new crystals, or even for the crystallization of other substances, and that all known reactions in which a solid phase results from another solid phase (by a nucleation mechanism) are localized in such zones of contact. Corrosion at these active lines (grain boundaries and inclusions) takes place according to this theory because they are also lines of preferential adsorption. At the same time, these active centers are centers of anodic activity. It has been found, 56 for example, that the grain boundaries in high-purity aluminum sheet are anodic to the centers of the grains.

Since these active centers or lines constitute only a small fraction of the total surface, the reactions taking place at these points or lines may be accelerated or retarded by very small quantities of positive or negative catalysts, such as the titanium ions in pre-dip solutions or arsenic in the phosphatizing solution.

The catalytic theory predicts that phosphate coatings are nucleated at active lines (grain boundaries) and that they stifle the anodic reaction by covering these anodic centers. As the number of anodic centers is thus decreased, the current density of the remaining local anodes is rapidly increased until passivation reactions take place. This is in agreement with Müller's Law of auto-passivation and with the observation that phosphates, when used as inhibitors, form metallic phosphates as the primary anodic product, thus stifling further attack.57 Metallographic examination of slightly phosphatized, polished surfaces reveals that the metal may be attacked in a number of ways by the same solution. Sometimes there is extensive etching first, while at other times well-defined crystals are formed at the surface without preliminary etching. Figure III shows a microscopic photograph of this. Often these crystals appear to be nucleated at grain boundaries. The variety of types of coatings that can be produced suggests that several mechanisms of coating formation may be possible, depending on the condition of the surface and the composition of the phosphatizing solution.

The determining factors of the phosphatization

process are related to the phenomena of dissolving metals, corrosion, and heterogeneous catalysis. Advances in these fields will contribute to an understanding of the mechanism of formation of phosphate coatings, and, in turn, the phosphatization process can be used as a tool in the study of these phenomena.

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#### COPPER FILMS

(Concluded from page 60)

Job and Reich20 record a series of organic copper compounds that have interest.

Mills, Crowe and Haun27 reactivate copper cyanide solutions by neutralizing and then adding alkali bisulphite and zinc to precipitate the metallic copper. Domange6 adds zinc to a solution containing chromic sulphate, getting both chromium and the zinc sulphate formed. The addition of copper sulphate and the chloride reduces the copper to metallic copper at once.

Crivelli<sup>3</sup> coated leaves and insects with copper films by using copper carbonyl.

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## **Chromising Steel Surfaces**

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A LTHOUGH chromising methods are a bit beyond the scope of the average metal finishing department today, the increasing interest which has been shown during recent years in the perfecting of previously developed technics is a strong indication that the field of its activity is gradually widening. In view of this interest, a thorough understanding of the process will be of advantage to all who are concerned with the corrosion protection of metallic surfaces.

Chromising is a general term covering various methods for producing on the surface of steel parts an integral layer high in chromium content. The coating is formed by means of a diffusion process in which iron atoms are gradually replaced by chromium atoms so that the resultant chromised layer is rich in chromium at the surface, showing a gradual decreasing chromium content with increasing depth.

#### History

Chromising was introduced to the industrial world less than a quarter century ago, with the idea in mind of producing a surface of extremely high corrosion resistance. Some of the main advantages claimed for the development are listed below:

- 1. Extremely high resistance to corrosion.
- Coating is integral with the surface, thus eliminating possibility of flaking or peeling.
- Coating is applied directly to steel surface, thus eliminating necessity for intermediate deposits.
- 4. Superior wear resistance.
- 5. Extended service life.
- Cost savings due to minimum chromium consumption.
- 7. Chromised surface may undergo bending and flanging operations without danger of spalling.

Prior to the last war there were several known methods for chromium impregnation. One technic, developed in 1921 by F. C. Kelley consisted of bringing low carbon steel in contact with powdered chromium heated in a hydrogen atmosphere to a temperature range of 1300 to 1400°C. This method did not prove commercially acceptable since the high heat requirements resulted in severe warpage and grain growth of the steel. Another procedure, utilizing a molten salt bath, received quite a lot of attention in Germany, but

difficulties in finding a crucible material able to withstand the corrosive action of the salt for the prolonged periods required at temperatures of 1100°C. limited it to the laboratory.

Before the flow of metallurgical information was cut off abruptly by the outbreak of hostilities, American and British research engineers had their eyes on the process developed in Germany by Becker, Daeves, and Steinberg. The BDS process, as it was called, appeared to be commercially acceptable and interest was extremely high just about the time the international barriers were raised. It was known that the process consisted of exposing the articles to be treated to a chromous chloride atmosphere under controlled temperatures. Laboratory tests, however, had revealed certain formidable limiting factors. First, chromous chloride is an extremely hygroscopic salt, unstable when exposed to the atmosphere and therefore difficult to use in industrial processes. Then too, it was known that the carbon content of the steel had a strong affect on the depth of chromium diffusion, as well as on the structure of the chromised surface, so that control of the coating was difficult. In spite of these difficulties, however, it was known that the Germans had succeeded in procuring a .004" depth of diffusion commercially, with a 35-40% concentration of chromium at the surface and a 13% concentration at the maximum effective depth.

It was natural, therefore, that as soon as the Germans surrendered, the British Intelligence Objectives Sub-Committee was sent into Germany to make a thorough study of chromising developments during the war. (Much of the material which is included below can be found in greater detail in the B.I.O.S. Final Report No. 839 which covers the results of an investigation of the various methods of gaseous metal treatment utilized by the Germans during the war.)

#### Typical Uses

The investigating committee found many examples of successful chromising on a broad commercial scale. Typical examples follow:

Chromised valves for controlling fluid flow.
 This application helped to conserve the scarce

copper-base alloys previously used, in addition to supplying superior corrosion protection.

2. Chromised bolts.

By chromising the bolts before the threads were rolled increased corrosion protection was afforded on the threads, and the chromised layer was work hardened by the rolling operation.

Chromised manifolds for internal combustion engines.

Reports indicate that these tubes operated satisfactorily at 850°C. even where the service at this temperature was continuous.

4. Chromised pre-heater tubes.

These tubes were used for preheating air for combustion in the engine of a destroyer. They operated at 750°C, with the air passing through while the fire passed around the outside. Tubes were examined at the end of 19 months service and found to be in very good condition.

5. Chromised milk cans.

This usage replaced stainless steel cans and resulted in a chromium savings equal to  $2\frac{1}{2}$  pounds per unit.

6. Chromised thin walled tubing.

This development permitted the use of low carbon steel tubing with its excellent drawing and fabricating characteristics in a number of installations which previously required the high corrosion resistance of stainless.

7. Chromised turbine blades.

Replaced chromium plating on exhaust gas turbine blades because of its non-scaling properties.

Even this partial list is sufficient to explain why the chromising process is again coming into the limelight.

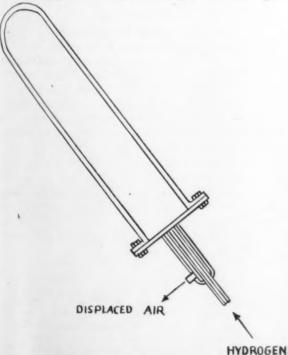


Figure 1—Preparation of chromous chloride—impregnated porcelain in B.D.S. process.

These results indicate that the limiting factors observed in the BDS process have been brought under control. From the data gathered it seems that the process was universally carried out in the two stages suggested by the patentees: first, the preparation of the chromising agent; and second, the actual chromising treatment. The same type of retort was employed for both stages of the process; a sketch of this retort is shown in Figure I.

#### Chromizing Procedure

PREPARATION

The steel retort, varying from 10 to 15 feet in length and two-to-three feet in diameter, is first filled with a mixture of porcelain such as broken, unglazed crockery, and ferro-chromium, in the proportion of 50/50 by volume, which represents about 70% ferro-chrome to 30% porcelain by weight. It is then inclined at an angle of about 45 degrees with the mouth downward and hydrogen is passed in through the center tube, displacing the air and driving it downward and out through the side tube. When the air has been completely replaced by hydrogen, the retort is placed horizontally in a gas-fired hearth type of furnace with the mouth end of the retort protruding into the open air. The temperature is then raised to 1000°C. and maintained there for five hours while hydrogen chloride gas is pumped into the retort. At the end of this period hydrogen is again passed through the retort, and it is then removed from the furnace and placed in the open air to cool. When the retort is sufficiently cool to permit handling, the porcelain mass is removed and stored for future use in the chromising stage.

During this preparation stage the chromous chloride is formed by the interaction of hydrogen chloride and ferro-chromium and is then absorbed into the ceramic material. The chemical reaction is as follows:

The use of porcelain as the "sponge" solved several of the problems which appeared to stand in the way of industrial application. The ceramic material acts as a stabilizer; by absorbing chromous chloride vapors and dilute chromous chloride solution it counteracts the hygroscopic nature of the salt. In this form it is relatively convenient to handle, easy to store, and can be used successfully several times before recharging. In addition, the broken porcelain can be measured for chromous chloride content by a simple specific gravity test, and can be recharged and used again and again.

#### CHROMISING

Chromising proper is carried out in the same retort, and the process is very similar to the preparation stage. The articles to be treated are first degreased and then packed into the retort along with the chromous chloride charged porcelain mass. After sealing the retort is placed in the furnace and heated as before for five hours at a temperature of 1000-1050°C. Reaction proceeds according to the equation

 $Fe + CrCl_2 \rightarrow FeCl_2 + Cr.$ 

The ferrous chloride is gaseous at the temperature

of operation and the chromium atoms deposit on and then diffuse into the surface of the steel. This movement results in a depth of diffusion rather than the mere formation of a mono-atomic chromium impregnated layer. After the heating period, the retort is removed from the furnace and allowed to cool.

The porcelain mass may be used for three or four treatments, but it then becomes necessary to recharge it by passing a small amount of hydrogen chloride into the retort during the chromising stage. The ferrochromium must be periodically replaced as it is ultimately consumed during processing. After a great many heatings and subsequent coolings the porcelain clumps get powdery resulting in a poor surface condition on the chromised articles, and a new batch of material must be used.

As the chromium diffuses into the steel the concentration at the surface reaches a maximum of 35-40%, falling rapidly with increasing depth below the surface. Up to a depth of approximately .004 inches an acid resistant coating is still provided. It has been found that the depth of diffusion varies according to a relatively fixed time-temperature curve. An increase in either time or temperature results in a thicker coating on low carbon steels, but temperature is considered the more potent factor and for economic reasons it is more advisable to increase the temperature than to increase the time of exposure, provided, however, that adverse effects on the steel are not brought about by too high a temperature.

The low carbon steels recommended for chromising are those containing 0.06% carbon and 0.5% titanium. The carbon content is the third important factor in controlling the depth of diffusion. In the high temperatures of the chromising process, the carbon of the steel diffuses toward the surface. It meets the inward diffusing chromium to form a carbide which precipitates around the iron grain boundaries and acts as an effective barrier against further chromium impregnation. The use of the 0.5% titanium is sufficient to precipitate a titanium carbide in the grains instead of the boundaries, thus permitting continued diffusion to a normal depth in the 0.06% carbon steel. When higher carbon steels are to be chromised, it is necessary that the steel contain adequate amounts of a strong carbide-forming element such as titanium, molybdenum or chromium.

#### **Experimental Developments**

Although the Daeves, Becker and Steinberg method of chromising was in full and successful commercial use during the war, various experimental approaches were made to the problem. One method employed gaseous diffusion at reduced pressure. A vacuum-tight retort was divided horizontally by a perforated shelf upon which were placed the articles to be treated. Chromous chloride was contained in boats placed on the floor of the retort. The atmosphere is reduced to a pressure of 20 mm. before it is heated to the 1100°C. at which temperature it is held for approximately five hours. Laboratory results on depth of diffusion tests using this process on titanium bearing steel approached those obtained with the BDS method.

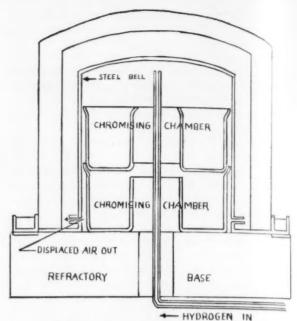


Figure II-Actual chromising of steel parts.

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Another approach developed experimentally during the war was one which was designed to overcome the previously noted limitations of the molten salt bath method. Krupp used a 25-25 nickel-chromium-iron alloy crucible and established a hydrogen atmosphere above the salt bath. It was ascertained that a mixture of 60% CrCl<sub>2</sub> and 40% BaCl<sub>2</sub> was best suited for maximum depth of diffusion in a minimum heating period. The mixture, maintained for four hours at 1100°C., produced a .0055 inch depth of diffusion. One difficulty encountered was the tendency for the chromous chloride to oxidize, necessitating the addition of metallic chromium to the molten salt bath.

#### Properties

Tests have shown that the actual corrosion resistance of chromised material is about equal to that of a 30% chromium steel. The appearance is dull, and the surface is relatively soft (compared to electro deposited chrome). Brinell hardnesses of 240 are average, and a chromised surface can be polished without difficulty. Whenever possible it is recommended that chromising be done after fabrication is complete, but it has been proven feasible to weld or braze chromised coatings provided the temperature is kept below 800°C.

Further refinements in the BDS and the experimental chromising processes are to be expected and it will be of interest to all concerned with corrosion protection to follow these developments in view of the commercial applications which have already proved successful in German industry.

#### References

- 1. A New Chromising Process, D. W. Rudorff, The Metal Industry, September 26, 1941.
- Chromising of Steel, Irvin R. Kramer, Robert H. Hafner, A.I.M.E. Technical Publication No. 1516, October 1942.
- 3. Report on Investigation of Methods of Gaseous Metal Treatment, British Intelligence Objectives Sub-Committee, Report No. 839, Item No. 21.

## Shop Problems

Abrasive Methods—Surface Treatments—Control Electroplating—Cleaning—Pickling—Testing

METAL FINISHING publishes, each month, a portion of the inquiries answered as a service to subscribers. If any reader disagrees with the answers or knows of better or more information on the problem discussed, the information will be gratefully received and the sender's name will be kept confidential, if desired.

#### Plating to Withstand Temperatures

Question: We have a problem in obtaining an impervious nickel plating on copper which will withstand firing at temperatures of 1350° F. without destroying the plating, or blistering. Is there anything you can suggest to help us?

Answer: Your question does not make clear whether you are plating nickel over a copper plate or on copper base metal direct. If plated over deposited copper, the copper deposit should be made from an acid sulfate bath. If plating directly on copper metal, the copper should be of the oxygen-free type. These are the only special precautions required, the nickel then being plated from a standard Watts bath by conventional methods.

Further information is contained in U.S. Patents 228548 and 228549.

#### Brown Spots from Copper Plating

Question: We are at times having trouble with our high-speed Copper solutions producing reddish-brown spots on the work, and not plating beneath the spots. We are using periodic reverse current and agitating the work. The bath composition is normal. Can you tell us how to overcome this?

C. R. S.

Answer: Your problem is undoubtedly due to uncertain and incomplete rinsing, which traps chemicals in any sub-surface pores. The reverse current technique is not involved in this difficulty, but should, if anything, tend to minimize it. Sub-surface holes are prevalent in most die castings and

often in wrought materials as well, and failure to rinse out any acids or other chemicals from these areas may give rise to a condition such as you have encountered. By performing only a limited amount of stock removal, in polishing, the denser surface metal on die castings can be preserved, and thus the sub-surface holes are rendered less harmful.

#### Hard Water

Question: We are having some difficulty in our burnishing barrels due to a scum forming on the parts. The water in this area is very hard, and we believe this may have something to do with it. Can you advise us on this problem?

Answer: One of the most obvious methods for eliminating a hard water problem would be to use de-mineralized water for your burnishing work. Units of various sizes for economical production of de-mineralized water are available from a number of manufacturers. Names are being sent to you.

It is also possible that you are not adding sufficient soap to overcome this hardness. You can check the amount required by measuring out a pint of the water into a clean, quart-size Mason jar, then adding small, weighed portions (about 1/4 ounce) of the soap you are using, shaking thoroughly after each addition until a lather remains for five minutes over the entire surface. This test will tell you how much soap is required to neutralize the hardness of the water. You should then use this same proportion of soap to water in your barrels, plus about two ounces for each gallon of water used, for lubrication purposes.

This test should be made whenever

you use a new barrel of soap, or whenever you suspect a change in the water, but need not be made any more frequently than this.

This method is a practical one for shop work. If you are interested in a laboratory method for absolute hardness, consult a textbook on commercial analysis.

#### Using Magnetic Materials for Plating Racks

Question: How practical is the use of permanent magnet materials for use in holding parts for plating?

H. G. S.

Answer: Permanent magnet materials have been used in some very ingenious and special plating rack setups, but their use must take into consideration the following disadvantages:

1—Magnetic materials are expensive.

2—Plating will build up on the magnet surfaces and will in time decrease the magnetic attraction.

3—They are only applicable for holding steel parts.

4—For holding large parts, large contact areas are necessary, and large contact areas would prevent plating over a considerable portion of the parts.

### Plating to Eliminate Porosity in Castings

Question: We have experienced difficulty with cast nickel valve bodies handling hot caustic solution leaking under pressure, and were wondering if nickel plating the inside of the valve body would overcome this difficulty?

Answer: We do not advise plating as a remedy for this type of trouble. About the only method that could be used would be to impregnate the castings with a plastic resin material that would withstand the corrosive action of the hot caustic soda solution. The names of firms that can give you more complete details on this process are being sent to you.

#### Finishes for Water Cooler Tops

Ouestion: We are making water cooler tops from stamped brass sheet, and would like to know how a black nickel or a bronze plating would stand up for this use?

L. P. B.

Answer: The standard finish for this type of service is a chrome plate over a heavy nickel deposit. Besides presenting a cleaner appearance, this type of plating would be superior in wear resistance and corrosion resistance from the water that will constantly be in contact with it. Black nickel and bronze plating would soon wear through, and the exposure of the underlying brass would not make a very attractive appearance.

#### **Brass Plated Cast Iron**

Question: Will cast iron parts that have been copper finished, bright nickel plated for 30 mins., and then brass plated for 3 mins. hold their brass appearance as long as parts that have been copper flashed and brass plated for 40 mins., buffed and lacquered? A. J. H.

Answer: In answering a question of this kind, it must be first decided what is meant by "appearance." If the retention of a bright lustrous surface is meant, then the amount of protection offered by the lacquer coating is the most important factor in this case. If

resistance to wear is important, the method using the heavy brass plating is best, since a slight wearing away of the surface metal will not expose the differently colored nickel plating underneath. This assumes, of course, that you do not buff away most of the brass deposit during the final coloring operation.

#### **Lead-Antimony Anodes for Chrome Plating**

Question: What are the advantages, if any, in using lead-antimony anodes for chrome plating instead of ordinary lead?

Answer: The principal advantage of the lead-antimony type of anode is in the decreased solubility of the anode in the chromic acid bath when the bath is idle and no current is flowing. This prolongs the life of the anodes and introduces less lead chromate film to the tank. Lead-antimony is harder than pure lead, which is usually of advantage from a handling standpoint, as they will retain a special shape better.

#### **Finishing Brass Castings**

Question: Can you tell me the method for finishing small brass castings to a high finish?

A. L. P.

Answer: The most economical method for finishing small castings is by barrel methods. With present day equipment and tumbling materials a very fine finish can be produced wholly in barrels, but if the highest type of finish is required the parts can be finished off by polishing and buffing in the conventional way. Some castings are also being electropolished, which gives a bright, lustrous surface of good appearance, even though the surface is left quite rough. The variables in barrel finishing are so numerous that it is impossible to give specific recommendations. Each case presents different problems, and most manufacturers of barrel finishing equipment will proc. ess sample parts for you and advise vou on the exact steps to be followed to produce the required finish.

#### Metallizing Baby Shoes

Question: Can you send me the name of a firm that is engaged in the metallizing of baby shoes, and where I can obtain mountings and bases for the shoes?

P. A. B.

Answer: We have for some time been compiling a list of shops that are doing this type of work, and a list of firms is being sent to you. Some of these are equipped to handle the work on a volume basis, and probably would be in a position to do your work for

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### **ELECTROPLATING CALCULATIONS**

The following tables may be used for calculating the times required to deposit various thicknesses of metals, current needed, etc. The table on Electrochemical Equivalents is based on a Cathode Current efficiency of 100%, and should be revised by using the proper Cathode Efficiency factor from the second table below for the bath under consideration.

Calculations using these tables cannot be relied on for extreme accuracy due to the wide variations in cathode efficiencies encountered in commercial operations, even with a given type bath. They are accurate enough, however for all practical purposes.

#### ELECTROCHEMICAL EQUIVALENTS

(Based on 100% Cathode Efficiency)

(1)	(2)	(3)	(4)	(5)	(6)	(7) Chemical	(8) Electro-	(9)	(10)	(11)	(12)	(13)	(14)
	Sym-	Val-	Atomic	Specific	Thickness o		chemical				Lbs. Per	Deposit in	
Element	bol	ence	Weight	Gravity	Deposits of		Equivalent	Coulombs/g.	g./Amp. Hr.	Hr.	1000	Inches Per	
	1				1 oz./Sq. Ft	Weight	mg./Cou- lomb				amp. nr.	Amp. Hr. Per Sq. Ft.	
Cadmium	Cd	2	112.41	8.65	.00139	56.205	0.58246	1716.9	2.0969	.073965	4.6229	.000103	0.971
Chromium	Cr	6	52.01	7.1	.0017	8.668	0.8980	11140.	0.3233	.01141	0.7128	.0000194	5.15
Cobalt	Co	2	58.94	8.9	.00136	29.47	0.3053	3275.	1.099	.03877	2.423	.0000526	1.90
Copper (ous)	Cu	1	63.57	8.92	.00135	63.57	0.6586	1518.	2.371	.08363	5,231	.000113	0.885
(ic)		2	63.57	8.92	.00135	31.78	0.3293	3036.	1.186	.04182	2.616	.000056	1.79
Gold (ous)	Au	1	197.2	19.3	.000686*	197.2	2.043	489.3	7.356	2365*	16.22	.000162	0.617
(ic)	Au	3	197.2	19.3	.000686*	65.73	0.6810	1408.	2.452	.07885*	5.406	.000054	1.85
Hydrogen	H	1	1.0078	.0695	133.6†	1.0078	0.010441	95766.	0.03769	.001329	0.08309	.1776†	0.0000
ndium	In	3	114.76	7.31	.00182*	38.25	.3964	2522.	1.427	.0457*	3.146	.000083	1.20
ron(ous)	Fe	2	55.84	7.87	.00153	27.92	0.2892	3458.	1.041	.03672	2.295	.0000563	1.78
(ic)	Fε	3	55.84	7.87	.00153	18.61	0.1928	5187.	0.6941	.02448	1,530	.0000376	2.66
lead	Pb	2	207.22	11.34	.001094	103.61	1.0737	931.35	3.8653	.13634	8.5220	.000145	0.690
Vickel	Ni	2	58.69	8.90	.00136	29.35	0.3041	3288.	1.095	.03862	2.415	.0000524	1.91
Palladium	Pd	2	106.7	11.40	.00116*	53.35	.2764	3618.	1.990	.0637*	2.194	.000069	1.35
Platinum	Pt	4	195.23	21.37	.000511*	48,808	0.50580	1977.0	1.8209	.058517*	4.0143	.000036	2.778
	Rh	3	102.91	12.5	.00106*	34.30	.2666	3751.	1.280	.0410*	2.116	.000044	2.29
Silver	Ag	1	107.880	10.5	.00126*	107,880	1.11800	894.45	4.0248	.12939*	8,8734	.000163	0,613
Fin(ous)		2	118.70	7.30	.00165	59.350	0.61506	1625.9	2.2142	.078103	4.8818	.0000129	0,775
(ic)	Sn	4	118.70	7.30	.00165	29.675	0.30753	3251.8	1.1071	.039052	2.4409	.0000064	1.56
Zinc	Zn	2	65.38	7.14	.00169	32.69	0.3387	2951.	1.219	.04300	2.688	.0000727	1.38

<sup>\*-</sup>troy ounces. †-gas at 32° F. 1 atm. pressure.

#### AVERAGE CATHODE CURRENT EFFICIENCIES OF COMMON PLATING SOLUTIONS

Metal	Type of Bath	Usual Cathode Efficiency—per cer	nt Metal	Type of Both	Usual Cat Efficiency—(	
Cadmium	Cyanide	88- 95	Lead	Fluoborate	100	
Chromium	Chromic acid-Sulfate	12- 16	Lead	Fluosilicate	100	
Copper	Acid Sulfate	97-100	Nickel	Acid Sulfate	94-	98
Copper	Gyanide	30- 60	Silver	Cvanide	100	
Copper	Rochelle-Cyanide	40- 70	Tin	Acid Sulfate	90-	95
Cobalt	Acid Sulfate	95- 98	Tin	Stannate	70-	90
Gold	Cvanide	70- 90	Rhodium	Acid Phosphate	10-	18
Indium	Cyanide	30- 50	Rhodium	Acid Sulfate	10-	18
Indium	Fluoborate	30- 50	Zinc	Acid Sulfate	99	
Indium	Acid Sulfate	70-80	Zinc	Cyanide	85-	90
Iron	Acid Chloride	90- 98		-,		
Iron	Acid Sulfate	95- 98				

**EXAMPLES:** To find the time required to deposit .0005" of Tin from an alkaline bath for a tank load of 10 parts having an area of 1½ square feet, at a total tank current of 500 amps.

From column 14 above, it requires 1.56 amp./hrs. to deposit .0001" for each sq./ft, of area, at 100% Cathode Efficiency. Therefore it will require  $5 \times 1.56$ , or 7.8 amp./hrs, for .0005" for each sq. ft. Since we have  $10 \times 1\frac{1}{2}$ , or 15 sq. ft. it will take  $15 \times 7.8$  amp./hrs. for the total tank load, or 117 amp./hrs. With a total current of 500 amps, the theoretical time required will then be  $117 \div 500$ , or .234 hrs. (14.0 mins.). But since the average cathode efficiency of the alkaline tin bath is only about 80%, our corrected time required is .234  $\div$  .8, or .293 hrs. (17.5 mins.).

#### **Patents**

#### Detergent Briquette

U. S. Patent 2,435,453. James Douglas MacMahon, assignor to The Mathieson Alkali Works, Inc.

A detergent briquette substantially free from a silicate, physically stable, hard, strong and non-deliquescent, consisting of a dense crystalline aggregate consisting essentially of the following constituents in proportion by weight within the respective indicated ranges total water about 30-50%, at least one detergent of the group consisting of sodium carbonate and trisodium phosphate aggregating from about one-tenth to about one-half the total formula weight, and at least one polyphosphate of the group consisting of tetrasodium pyrophosphate, sodium tripolyphosphate, sodium tetraphosphate and sodium hexametaphosphate aggregating about 5-50%, but not exceeding about 15% of sodium tetraphosphate and sodium hexametaphosphate.

#### Continuous Method for Electropolishing Nickel and Nickel-Containing Alloys

U. S. Patent 2,440,715. Charles L. Faust and Paul D. Miller, assignors to Battelle Development Corp.

The method of electrolytically polishing metal selected from the group consisting of nickel and nickel alloys containing at least 90% nickel, which comprises making the metal the anode in an aqueous bath having a dissolved chloride ion content calculated as HCl of from 0.04 to 2.5% by weight of said bath, the remainder of said bath consisting essentially of a composition lying within the closed area defined on the accompanying diagram by the solid straight lines AC, CD, DE, EF, FG, GH and HA, passing through said solution while held within the temperature range of from 80° to 140° F. an electrical current of sufficient density and for a sufficient period of time to effect the polishing of said metal, and during said electropolishing maintaining said bath at that temperature within said range at which anodically dissolved nickel will be electrodeposited from said bath whereby the tendency of nickel salts to precipitate on continued operation of said bath is reduced.

#### Electroplating Bath for Silver

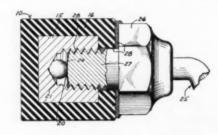
U. S. Patent 2,440,672. Harry J. Green, assignor to General Motors Corp.

A silver-cyanide plating bath comprising essentially an aqueous solution of silver cyanide and an alkali metal cyanide to which has been added 0.05 to 12.5 ml. per liter of a brightener comprising essentially an aqueous solution of ammonium thiosulfate, an alkali metal sulfite and acetic acid, said brightener having a specific gravity of approximately 1.305 to 1.311 and a pH of approximately 4.12 to 4.25 at 25° C.

#### **Electroplating Rack**

U. S. Patent 2,439,190. Leroy E. Schroeder, assignor to Western Electric Co., Inc.

An article supporting rack for electroplating comprising an insulation



coated frame of electrical conducting material, an insulation coated cross bar thereof having a screw-threaded cavity terminating in a cone-shaped inner end wall, a deformable contact pellet of conducting material engaging in the cone-shaped inner end wall, and an article supporting and electrical conducting hook having a screw-threaded portion fixedly threaded into the cavity under compression against and deforming said contact pellet to insure a positive electrical contact between said bar and hook.

#### Method of Tumbling Barrel Finishing and Materials

U. S. Patent 2,439,156. Carl H. Castle, assignor to The Sturgis Products Co.

The method of polishing comprising the steps of tumbling the work with fragments of stone of the limestone group, to remove flash, sharp corners and surface irregularities from the work, introducing a solution which reacts with content of the stone to cover the limestone fragments with a coating filling and covering the abrasive surface irregularities of the limestone, and

again tumbling and continuing the tumbling after the limestone fragments have acquired such coating.

#### Metal Cleaning Composition

U. S. Patent 2,440,837. Hugh G. Webster, assignor to J. H. Shoemaker,

A metal cleaner comprising an aqueous solution of an alkali metal hydroxide, an alkali metal borate, and an alkali metal cyanide, in proportions, by weight, of 50-90 parts, 4-10 parts, and 5-46 parts, respectively.

#### Indium-Gold Article and Method

U. S. Patent 2,438,967. Harold D. Ellsworth, assignor to The Indium Corp. of America.

An indium-gold surfaced article which comprises a surface film composed of an indium-gold alloy the indium being present in proportion not less than 10% and the gold in proportion not less than 50% at the surface, an under layer of gold containing not over 8% of indium and an intermediate layer in which the proportion of indium increases gradually toward the surface.

#### Work Carrier for Electroplating

U. S. Patent 2,440,019. Leon J. Pianowski and Sam F. Sgriccia, assignors, to The Udylite Corp.

A work carrier for electroplating comprising a pair of similar members adapted at one end for suspension from a rail in juxtaposition and contiguous to each other and adapted for engagement with the rail to an appreciable extent both laterally and longitudinally of the rail, each of the contacting surfaces of said members at said end having a protuberance toward the other member, the two protuberances engaging each other to permit a rocking movement of said members. the lower ends of said members being shaped for the suspension of work therefrom.

#### Insulating Cover for Bus Bars

U. S. Patent 2,439,859. George I. Muller assignor to Taylor Fibre Co., Inc.

An insulating covering of tubular shape for a conductor bar having a layer of dielectric material on the inner surface, a layer of foraminous conducting metal on said inner layer of dielectric material, a plurality of layers of dielectric material wound on the layer

## ALUMINUM CLEANING MADE EASY



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Cowles 352 Cleaner is especially designed for pressure type and other standard type washing machines. It incorporates all of the desirable characteristics of AE Cleaner but will not foam.

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## The Cowles Detergent Company

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of toraminous conducting metal bonded to each other by an insulating cement, portions of the foraminous conducting metal extending through the inner layer of dielectric and portions of the dielectric thereon.

#### **Treatment of Iron Sulfate Liquors**

U. S. Patent 2,440,215. Louis N. Allen, Ir., and Walter K. Zahray, assignors to Chemical Construction Corp.

A method of treating a ferrous sulfate liquor containing free sulfuric acid which comprises adjusting the acidity of said liquor to a pH within the range of from 2 to about 4.3 and reducing any ferric iron that may be present to the ferrous condition by adding to the liquor a metal above hydrogen in the electromotive force series of elements, heating the liquor to a temperature of at least 100° C., subjecting the liquor to a settling process at said elevated temperature and thereby separating therefrom a ferrous sulfate sludge.

#### Solvent for Degreasing Iron and Aluminum

U. S. Patent 2,440,100. Walter Klabunde, assignor to E. I. duPont de Nemours & Co.

A liquid solvent composition for degreasing iron and aluminum consisting essentially of trichlorethylene and 0.02 to 1% by weight of an inihibitor for condensation reactions of trichlorethylene catalyzed by the aforesaid metals, said inhibitor being a thiophene selected from the group consisting of thiophene, 2-methyl thiophene and 3-methyl thiophene.

#### Indium Electroplating

U. S. Patent 2,439,935. Thomas R. Jones and Nevin R. Bierly, assignors to The American Metal Co., Ltd.

A process for electrodepositing indium which comprises, electrolyzing an aqueous solution of perchloric acid with electrodes including a substantially pure indium anode until an electrolyte consisting of indium perchlorate in water with some free acid is formed, adjusting the indium content thereof to about 20 to about 60 grams per liter and free perchloric acid content to about 1 to about 75 grams per liter, employing a substantially pure indium metal as anode and a bearing as cathode in said electrolyte, and electrodepositing indium of the bearing

surface of said bearing, adjusting the current density to about 10 to about 55 amperes per square foot, voltage to about 0.6 to about 2.5, and the temperature of electrolyte to about 75° F. to about 130° F.

#### Reduction of Foaming in an Aqueous Bath Containing Foam-Inducing Constituents

U. S. Patent 2,439,797. Wayne L. Denman, assignor to Dearborn Chemical Co.

The method of treating an acqueous bath having present alkaline constituents inducing foaming therein comprising reducing the foaming of the bath by introducing into the same a mixture of a halogenated aliphatic amine and a hydroxy aliphatic amine, each of said amines having at least eleven carbon atoms in an alkyl radical thereof and being substantially insoluble in the aqueous bath, and showing little tendency to saponify with the ingredients of the bath.

#### Conductor Roll

U. S. Patent 2,439,858. Earll R. Muddiman and William E. Winterhalter, assignors to Carnegie-Illinois Steel Corp.

Apparatus for electroplating metal on a continuously rapidly moving strip of dissimilar metal, which comprises a combined conveyor and conductor roll for conveying the strip through an electroplating bath, the said roll also contacting and supplying electric current to the strip as it moves through the plating bath and making the said strip the cathode in the bath, the said combined conveyor and conductor roll comprising a hollow electrically conducting cylinder, a conductor shaft for mounting the cylinder, current conducting diaphragms between the cylinder and shaft in conducting relation therewith, the said diaphragms having a diameter equal to the inside diameter of the cylinder and being spaced equally along the shaft and cylinder and at equal distance within the ends of the cylinder, the said diaphragms uniformly distributing current over the entire cylinder, electrically conducting end closure members for the cylinder in tight engagement therewith and with the shaft, the said closure members being of less conductivity than the diaphragms, and forming auxiliary current conducting and distributing members cooperating with the diaphragms for uniformly distributing the current over the entire cylinder, the said closure members being extended into tapering hubs engaging the shaft, current collecting drums in tight engagement with the shaft, and means in the shaft for circulating cooling fluid through the cylinder.

#### Degreasing Apparatus

U. S. Patent 2,442,272. Mose Jaffa, Brooklyn, N. Y.

A degreasing device comprising a tank, said tank having upstanding tank. walls and a bottom tank-wall, an electric heater associated with said tank. heat-transmitting means associated with said heater, said heat-transmitting means being located in said tank adjacent its bottom tank-wall and being fixed to said tank, a frame located in said tank, said frame being movable relative to said tank, said frame being shaped to rest on said bottom tank-wall. said frame having upstanding framewalls and a top frame-wall, one of said upstanding frame-walls having a slot therein, said heat-transmitting means extending through said slot and being located between said top frame-wall and said bottom tank-wall when said frame rests on said bottom tank-wall. said frame being open at its bottom to clear said heat-transmitting means when said frame is raised and lowered. said frame having upstanding supporting means fixed thereto, a cover for said tank, said cover being connected to the top of said upstanding supporting means, said cover closing said tank when said frame rests on said bottom tank-wall, said tank having an external exhaust-casing fixed to said tank adjacent the upper end of said tank, the top of said exhaust casing being below said cover when said cover is in closing position, the upstanding tank-walls having perforations at said exhaust casing to provide communication between said tank and the interior space of said exhaust-casing, said exhaustcasing being closed save at an outlet port in the outer wall of said casing. a spray pipe located in said tank below said perforations, pumping means for pumping liquid from the bottom of said tank to said spray pipe.

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#### Low-Cost Vari-Plater

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Lewis Electrical Mfg. Co., Dept. MF, 1443 Walton Ave., New York 53, N. Y. A new, versatile Selenium Rectifier



Vari-Plater, Model No. A-10, for plating gold, silver, chromium, nickel, copper, cadmium, etc. on metals, as well as non-metals, is now in production, it was announced today by the above firm.

The Model A-10 vari-plater is a complete packaged electroplating unit, requires a minimum of space and can be operated immediately upon installation. Standardization of design and rating has made this an economical unit that can be immediately purchased from stock.

Some of the features are: variable DC voltage (from zero to maximum)—versatile, works in tandem (several units can be combined to raise voltage or amperage)— instantaneous DC power (merely plug into 110V AC source, no warm-up period required)—economical to operate—conservatively rated, skillfully designed and engineered and sturdily constructed of standard, replaceable parts.

#### New Chemical-Resisting Tape

United Chromium, Inc., Dept. MF, 51 East 42nd Street, New York 17, N. Y.

A synthetic resinous tape, which resists chemical attack, aging, and insulates electrically, has been announced by United Chromium. Known as Unichrome Tape 705, this product is designed especially for use by the electroplating industry as a coating for racks or for stop-off purposes. However, it is said that its properties will find a wide application in other fields, wherever chemical resistance or a flexible, easily handled insulator is required.

Unichrome Tape is said to resist severest plating baths, hot cleaners, pickling solutions, electrocleaners, anodizing. Tests have revealed no deteriorating effects on the tape by cyanide copper bath or alkaline cleaner. It is reported that tape tested 48 hours in chromic acid had a negligible weight loss, which is claimed to be proof of outstanding chemical resistance.

Unichrome Tape is green in color, with a smooth, "slick" surface. Its elasticity permits snug taping without pockets. Wrappings are anchored by cementing down only ends of tape. Cementing may be dispensed with if desired, and the tape fused into one continuous coating by baking at 275° to 300°F for 15 to 30 minutes.

#### Liquid Plastic Plating Rack Coating

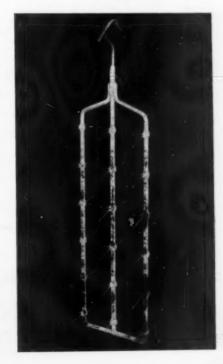
Enthone, Inc., 442 Elm Street, Dept. MF, New Haven, Conn.

The above firm has announced the development of a new liquid plastic plating rack coating called "Enthonite 101." This material is supplied as a viscous liquid containing 100% solids,

which is applied by dipping to produce coatings varying in thickness from \(\frac{1}{3}\)''. The material is applied over a primer coat and is baked at temperatures of 350°F, or higher for a short period of time.

No loss is experienced with the use of this material because there are no solvents to evaporate and all drippings can be reclaimed and reused. The coatings produced are stated to have very high resistance to all types of inorganic solutions, particularly plating solutions, including chromium solutions. The surface produced is glossy, so that solutions do not readily wet it and considerable saving and dragout of solution is claimed. The coatings produced are tough and resilient and will not chip even on rough abuse of the plating rack, according to this firm.

Racks coated with Enthonite 101 are being used in full automatic plating cycles involving the use of strong alkali cleaner, strong acids, acid or





\* "The Siefen System" is rapidly becoming a familiar term for the fast, efficient and economical way of applying buffing and polishing compound to revolving wheels.

"The Siefen System" for spraying compounds is—

FAST—better cutting and coloring EFFICIENT—no work stoppage ECONOMICAL—save over 60%



#### PROPER SPRAY EQUIPMENT

SIEFEN has developed through experience, efficient spray guns, operating valves, hose and fittings, baffles, circulating pumps, pressure tanks or gravity cups for hand or automatic operation.



# BUFFING AND POLISHING SPRAY COMPOUNDS

SIEFEN liquid compounds, either grease and abrasive or glue and abrasive, eliminate guess work and really reduce costs.



#### **EXPERIENCED SPRAY SERVICE**

SIEFEN specialists, all over the country are ready to give you the latest, most up-to-date help and recommendations for improving speed and quality, increasing efficiency and cutting production costs.

J. J. SIEFEN COMPANY
5627 LAUDERDALE DETROIT 9, MICH.

alkaline plating solutions and chromium plating solutions. The resistance to attack or absorption by chromic acid is claimed to be an outstanding feature of this product.

Repair of the coatings for replacement of hooks is done very easily by the use of a patching cement and a radiant energy heat lamp. Due to its outstanding resistance to attack by inorganic chemicals, Enthonite is being used and is recommended for coating of tanks, work holders, and acid dipping baskets. The manufacturers have subjected the coating to continuous plant trials for the past year before making the material available to the general public.

Samples of racks can now be coated or sample coated rods will be furnished customers for examination.

#### **Insulated Dipping Baskets**

Automotive Rubber Co., Inc., Dept. MF, 8601 Epworth Blvd., Detroit 4. Mich.

A new standard line of insulated baskets for dipping, pickling and general use in submerging parts or products in corrosive solutions is announced by this firm.

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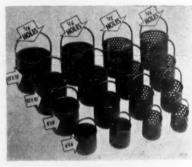
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The new baskets, fabricated of heavy gauge, reinforced, perforated steel with welded joints, are completely



covered with \(^1/8''\) thick, shock-proof. semi-hard pure rubber.

The Arco process provides for coverage of all faces of the hole with rubber, small perforations being filled solid and drilled out. Thus positive protection for both basket and solution is assured.

Four sizes of perforations are offered with finished hole sizes of: 1/8", 1/4", 1/2" and 3/4".

Four sizes of baskets are offered in each hole size: 12" diameter by 12" depth, 10" by 10", 8" by 8", and 6" by 6". Rigid bails welded to the body are also completely rubber covered.

Special sizes and shapes will be made

to specifications. A catalog sheet covering the line is available on re-

#### Heavy Duty Selenium Rectifier Stack

International Rectifier Corp., Dept. MF. 6809 S. Victoria St., Los Angeles 13. Calif.



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The above illustration shows a recently developed heavy duty selenium stack. This stack, in three phase half wave circuit, will deliver 1500 amperes and 9 volts continuous load. The required air velocity is of the order of 800 linear feet per minute. This stack consists of 34 (61/4"x 71/4") selenium elements. Each element is individually moisture-proofed in order to provice adequate protection against corrosive atmospheres, such as encountered on board ship, in plating shops, etc. The terminals are 1/4"x 1/2" copper busses. The mounting of the terminals is arranged in such a way as not to obstruct the air flow from the fan. The entire unit is rigidly assembled and is therefore well suited for mounting on mobile equipment.

#### **New Rack Coating Tape**

Hanson-Van Winkle-Munning Co., Dept. MF, Matawan, N. J.

A new and improved orange-colored Wrap-Rax, a synthetic resin in easy-to-use tape form for insulating plating racks, is announced by the above firm. It is effective as a stopoff in hard chromium and other plating solutions.

Wrap-Rax is said to have the following advantages:

1. Durable—tough, plastic, resists abrasion and wear. Chemically resists all cleaning, pickling and plating solutions commonly used.

2. Uniform coverage—edges and flat surfaces are covered equally.

3. Clean and safe—easy to use as friction tape; no dripping liquids, toxic or inflammable fumes.

Wrap-Rax prevents disintegration



MAGNUS specialized lubricants and burnishing compounds are the result of a quarter of a century of development work in the field of tumbling and burnishing. Many of the standard compounds now offered are the result of long, hard research to solve particular problems in these finishing operations. And we are still called on to solve special problems along these lines.

All the Magnus materials recommended below have been tried and proved in many plants. They can do an equally good job for you.

#### TUMBLING

This cutting down operation is materially improved by the use of Magnus #25 for steel, Magnus #58-HL for brass, and Magnus # 58 on aluminum or die cast parts.

BURNISHING Magnus burnishing compounds insure development of high luster without overheating and without abrasion of the parts. They offer faster burnishing and complete rinsibility after the burnishing job is done. Usually only 4 oz. to 100 lbs. of work are required.

For steel and stainless steel, Magnus #52-B has proved highly economical and satisfactory. \$58-HL is recommended for brass and copper, \$58 for aluminum, and 17 for die castings.

#### **DE-BURRING**

Removal of undesired metal by manual methods like grinding and filing is not only expensive but undependable. Suitable modification of tumbling technique plus careful selection of Magnus lubricants will enable you to limit your cut to projecting burrs, while surfaces that otherwise would tend to rub each other are protected from abrasion.

You can de-burr with the proper Magnus lubricant many times faster and much more dependably than by manual methods.

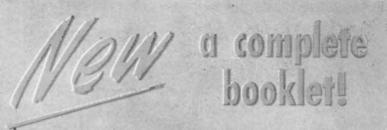
If you have any problems in tumbling, burnishing or de-burring, ask us to help. The right Magnus lubricant may solve them!

#### MAGNUS CHEMICAL COMPANY

11 South Ave., Garwood, N. J.

In Canada-Magnus Chemicals, Ltd., 4040 Rue Masson, Montreal 36, Que. Service representatives in principal cities



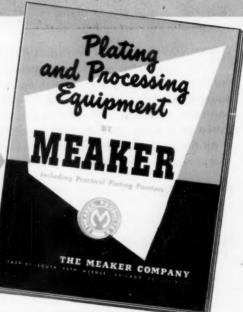


ELECTROPLATING MACHINES

PRACTICAL PLATING POINTERS

Plating Data Tables

Write for Your Copy



# the profitable way to do it

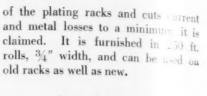
Making every operation in a plating sequence as automatic or as mechanized as possible is the profitable way. This new booklet illustrates and describes a variety of ways it is done with Meaker Machines Not only is the cost lower, but the production is increased, and a better and more uniform quality of product is assured.

You should get a copy of this booklet for ideas on improving your plating processes. The Practical Plating Pointers including several new tables are a convenience for those in charge of plating departments.

# THE MEAKER COMPANY

1629-41 South 55th Ave., Chicago 50, Illinois

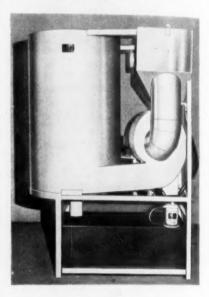
Full Automatic and Semi-Automatic Electroplating Equipment • Strip Steel Plating Equipment • Wire Galvanizing Equipment • Strip Steel Electrocleaning Lines • Pickling Machines • Processing Conveyors Motor Generators for Plating • Rectifiers for Plating



#### **Dust Separator**

Industrial Electroplating Co., Inc., Dept. MF, 219 W. Vermont St., Indianapolis, Ind.

The above firm has begun manufacture of a second unit in its line of industrial air cleaning equipment which incorporates principles of water action and centrifugal separation.



The newest unit, the Niehaus Dust Separator, employs wet methods to remove from the air the dust and foreign particles that result from polishing, buffing and grinding operations. The unit thoroughly mixes finely divided particles of water with dust-laden air, and by centrifugal action, washes out the entrained foreign material.

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The clean air is discharged out of the top of the machine into the shop, eliminating all heat loss common to machines that discharge out-of-doors. The unit contains its own blower and water recirculating systems. Refuse is collected in a portable tank beneath the unit, making disposal or reclamation easy, it is claimed.

The Niehaus Dust Separator contains no filters or bags to clog up or be replaced, and the wet methods employed eliminate fire hazards. It is designed to provide a two-inch static pressure for exhausting four regular size buffing or polishing wheels up to 16 inches diameter. Where conditions require, the unit supplies four-inch negative

pressure for three wheels, and a maximum of six inches pressure is available for exhausting two wheels.

The unit is delivered complete with motor, pump and motor controls, and is designed to be placed alongside the machines being exhausted.

#### Water Emulsion Wax for Rust Prevention

S. C. Johnson & Son, Inc., Dept. MF, Racine, Wisc.

A water-emulsion wax that is now being successfully used as a rust-inhibiting coating for metals has been developed by the above firm. It is



being marketed as Johnsons Rust-Inhibiting Wax No. 1568.

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Applied by conventional dipping, spraying, wiping or flow-coating, this emulsion forms a dry wax plating on the metal part that checks corrosion. It is non-flammable and non-toxic and gives high coverage of between 2500 and 3000 square feet per gallon...can be readily removed by degreasing if desired.

Johnson's 1568 Wax is now being used as a corrosion inhibitor on black-exidized, phosphated and untreated metal surfaces. It is also being used on painted and plated parts as a safeguard against scarring and chippping. Typical parts treated are shown in the accompanying illustration.

Descriptive literature on this product is now available by writing to the manufacturer.

#### Water Dispersing Agent

M. & M. Chemical Co., Dept. MF, 1559 W. Main St., Willimantic, Conn. Announcement has been made by the

## Put the



# on burnishing problems

No matter what your burnishing problems may be, you'll find the answers in the *complete* Wyandotte line of burnishing compounds.

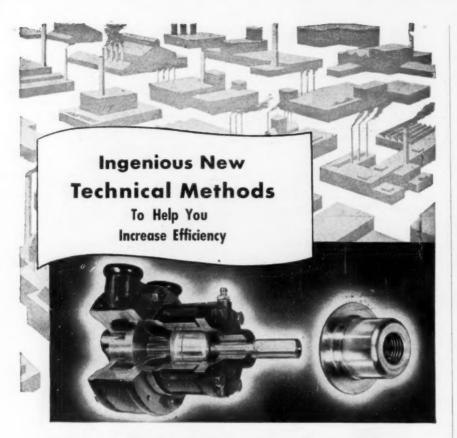
Wyandotte Burnishing Compound 317 gives a high luster to parts of zinc, nickel and Monel metal. It works effectively in either hot or cold water. And because this viscous liquid contains no soap or inorganic alkalies, its burnishing action is not affected by the hardness of water. It rinses freely and leaves no scum on the work or in the barrel. Wyandotte Burnishing Compound 320 gives a highly satisfactory finish to brass, copper, bronze, carbon steel or stainless steel. It is a soap-type compound and contains a non-toxic brightening agent. It may be used for burnishing with steel balls or for combined burnishing and burring with chips or stones.

Your Wyandotte Representative will be glad to tell you more about these and other specialized Burnishing Compounds in the complete Wyandotte line. All you have to do is give him a call.



WYANDOTTE CHEMICALS CORPORATION

WYANDOTTE, MICHIGAN . SERVICE REPRESENTATIVES IN 88 CITIES



# New Cartridge Seal Solves Rotating Shaft Sealing Problems

Stepped-up efficiency in sealing of rotating shafts can now be accomplished with a new Cartridge-type Seal mounted on the shaft.

The Cartridge-type Seal shown above is mounted within a Tuthill Pump. The seal contains all parts in one housing cup and insures positive double sealing. A high grade permanent lubricant is contained within the inside chamber of the housing.

Surfaces within the Cartridge-type Seal are lapped flat to within a few millionths of an inch to insure perfect mating. And, being a complete unit, only one mounting face is necessary. Clamps are eliminated, and adjustments or alignments are not required. Simply push the Cartridge-type Seal onto the shaft, tighten mounting screws and that's all.

Just as new engineering developments increase efficiency and performance, so can workers' efficiency be increased through the use of chewing gum. The act of chewing helps relieve nervous tension, thus helping to make the work go smoother and easier. That's why plant owners everywhere more and more are making Wrigley's Spearmint Chewing Gum available to all.

Complete information may be obtained from Cartriseal Corporation 200 No. Lastin Street Chicago 7, Illinois



Cartridge-type Seal



AC-71

above firm of their new water dispers. ing agent for use after plating and rinsing cycles to displace water from the surface of parts and thus facilitate drying without the formation of films. Called Marco No. 410, the material is supplied as a liquid that is used in the proportion of 1 quart to 50 gallons of hot water. It is introduced into the plating cycle after the final rinse, and does not leave any film or residue on the finished parts, according to the manufacturer. In several instances where parts were formerly tumbled in sawdust for drying after plating, the use of this water dispersing agent has eliminated the need for the sawdust operation, it is claimed.

#### Corrosion Resistant Coating Material

Ceilcote Co., Dept. MF, 612 N. W. Superior Ave., Cleveland 13, O.

An acid and alkali proof lining material for fume carrying ducts is now being offered for general use by the above company, which has specialized for 25 years in acid proof materials. The new product, known as Ceilcote Spray Grade, has been under continuous tests for a number of years by several of the country's largest electrical manufacturers with results which make the manufacturing company willing to offer guaranteed performance.

The material is proof against acids and alkalies and has a maximum temperature resistance of 300 degrees F. It bonds to either wood or metal to an exceptional degree, it is claimed. Application is by special spray equipment which builds a lining up to ½ inch thickness, affording expansion and absorption and eliminating cracking from vibration. It is offered on an installed basis, or for those desiring to make their own installation, special spraying equipment is available on a rental basis.

#### Removing Lime Scale from Heating Coils

Allied Products Co., Dept. C52, 1133 Newport Ave., Chicago 13, Ill.

A coil that is coated with lime and mineral scale operates at reduced efficiency and is costly by wasting fuel and heat. A new, inexpensive and easy to use liquid which desolves lime scale and renews the efficiency of hot water coil-equipped apparatus or hot water tanks of automatic heaters has been an-

nounced by the above firm.

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The material is easy to use; it is only necessary to bring the liquid in centact with the scale. It immediately goes to work, and foaming action indicates that the scale is being dissolved. When foaming stops the unit



The manufacturer claims that Corodex Coil Clean will completely dissolve all lime and mineral deposits from copper, brass, bronze, iron or steel or stainless steel coils. Also, hot water and steam coils, steam tables, tanks, refrigerator drains, processing kettles, unit coolers, condenser coils, compressor jackets, spray heads, sterilizers and any type of equipment can be cleaned without injury to the coil or other parts. The coil does not have to be removed and even a completely lime-blocked passage can be opened.

Corodex Coil Clean is non-explosive, non-inflammable and will not injure the metal or the hands of the user, it is claimed. It is available to industrial users and home owners in any quantity from one gallon to fifty-five gallons.

#### Stop-Off for Selective Tin Plating

Acheson Colloids Corp., Dept. MF, Port Huron, Mich.

"Dag" Dispersion No. 38 used for the above purpose, is a concentrated dispersion of semi-colloidal graphite in resin and naphtha. Before using it should be mixed with equal parts of toluene then applied either by brushing on spraying on that part of a surface where it is found necessary to prevent the adhesion of tin.

It is important to completely cover the treated area and then force dry the film of graphite and resin for 15 to 30 minutes at 250° F. to 400° F.

To cite an example of its utility; a large nationally known manufacturer of tin plated bearings wanted to plate enly the inside surface of a sleeve type bearing by hot dip tinning. By treating the outside or back surface of the bearing as noted above they were able to



\*...this is the expression of finishers who use the Presto Contact Wheel . . . its smooth, cool running, balanced operation gives it a distinctive feel of competent performance . . . there is less fatigue on operator.

Here is a wheel that will not burn under the severest working conditions . . . even under automatic or semi-automatic operation . . . the results

are excellent on hot jobs.

The Presto Contact Wheel is made of molded Neoprene . . . the face density is accurately controlled and is even throughout . . . it does not soak up oil or grease. It is securely vulcanized and anchored through beveled holes in rim . . . it is safety tested at 5000 R.P.M. before shipping. The Presto Contact Wheel is available for 1 inch to 134 inch shafts.

The Presto Contact Wheel is available in 14-inch diameter with face widths of 2, 3 or 4 inches. They are so constructed that a 6-inch face can be secured by mounting a 4-inch and a 2-inch width wheel together. Densities, based on durometer test, are as follows: 50-fine polishing, 60fine polishing slight stock removal, 70-medium removal, 90-heavy stock removal and snagging.

For prices and complete details write to the address below.

- \* Even density face.
- \* Long life.
- \* No breakdown of face or sides.
- ★ Will not burn under severest use.
- \* Smooth . . . cool running.
- \* One-piece hub includes arbor hole.
- \* For automatic or semiautomatic finishing.
- \* Perfectly balanced.
- \* Made of Neoprene.
- \* Not affected by oil or grease.
- ★ Available 50, 60, 70, 90 (durometer test).

## PRESTO Back Stand Idlers Feature Low Initial Cost!

The Presto Back Stand Idler is of sturdy, allsteel, vibration-free construction . . . equipped with double-sealed precision ball bearings. It can be changed easily from right to left by loosening two set screws and reversing shaft. Adjustable belt tension is maintained by six leaf-type springs. Its initial cost is very economical and its performance is "tops".



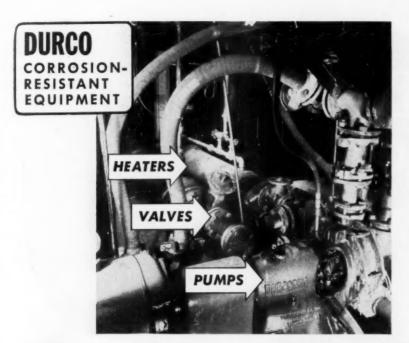
Without moving base, it adjusts to run close to equipment with a short abrasive belt or standard 168" abrasive belt.

Selective Distributorships Available

CHICAGO 7, ILLINOIS

BACKSTARD IDLERS - CONTACT WHEELS - TUBE POLISHING MACHINE SPINNERS - BUFFING WHEEL RAKES - POLISHING WHEEL BUSHINGS -POLISHING LATHE WRENCHES, FLANGES, COLLARS & NUTS - SCREW POINTS EMERY TROUGHS - BALANCE WEIGHTS & WATS - TUBE SUPPORT STAND

. METAL FINISHING SUPPLIES AND EQUIPMENT .





Durco equipment is able to withstand corrosive service like this because every part that comes in contact with the corrosive is made of DURIRON. This Durco high silicon iron is completely resistant to practically every plating solution.... copper, chrome, nickel and others.

For maximum plating service with minimum maintenance, specify Durco equipment.

For further information—on Durco valves write for Bul. 610; on Durco pumps write for Bul. 815; on Durco heat exchangers write for Bul. 1603.

THE DURIRON CO., INC., DAYTON 1, OHIO

Branch Offices in Principal Cities



Standard Durco "packaged" units are available with one to nine or more heat exchangers in banks—together with the necessary corrosion-resistant valves, pipe, fittings and pumps—supported on one frame. For further information on typical layouts ask for folder I.



DURCO Adv. 68-GM

accomplish their purpose and were so impressed with the performance of the film and its ability to withstand muriatic acid pickling baths, as well as the fluxing dip and molten tin dip, that they adopted its use for all of their production.

"Dag" Dispersion No. 38 is available in 8 pound, 40 pound, 120 pound, 224 pound and 400 pound containers.

#### CORRECTION

The June issue of Metal Finishing contained an announcement of a small filtering unit manufactured by Sethco, in which it was stated that capacities up to 250 gals. per minute were obtainable with this equipment. This should have read 250 gals. per hour. We regret this error in typography.

#### Rectifier for Plating Jewelry and Other Small Parts

Hoover & Strong, Inc., Dept. MF, 119 W. Tupper St., Buffalo 1, N. Y.

The above company has announced a small rectifier unit for use in plating jewelry and other small parts, together with prepared solutions ready for use. Solutions available are cadmium, copper, gold (various colors), nickel, palladium, rhodium, silver, and zinc. The output of the rectifier is 4 amperes at 6 volts, and several units may be hooked up in parallel to give larger outputs for plating larger objects. A free instruction booklet on how to plate various objects is included with the unit. The cost of the rectifier unit plus solutions



for copper and gold plating, electrocleaning and stripping is less than \$20.

#### Portable Silver Plater

Rapid Electroplating Process, Inc., Dept. MF, 1414 S. Wabash Ave., Chicago 5, Ill.

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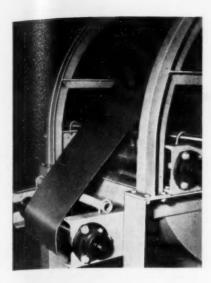
The above firm announces a portable silver plating outfit using the brush technique for plating and refinishing metallic parts. The outfit consists of a plating rectifier of 16 ampere, 0-8 volts output from a 110 v. AC inlet, polishing block for cleaning parts before plating, 16 oz. of Metal Cleaning solution, 16 oz. of Silver Electrolyte, 2 Silver Applicators, and a Coating Tester for quick shop tests. Solutions are also available for plating Nickel, Cadmium, Tin, Zinc, Copper, Brass, Lead, and Gold. One of the most common uses for this equipment has been for the silver plating of bus bar connections for good electrical contact, and for plating the contact areas of switches, starters, etc.

#### Continuous Filter for Neutralized Waste Pickle Liquors

Filtration Engineers, Inc., Dept. MF, 858 Summer Ave., Newark 4, N. J.

Announcing a new, small, continuous vacuum filter as the easiest way to abide by state pollution laws and get rid of the nuisance of waste pickle liquor disposal, this firm culminates several months of joint research with steel mills, neutralization process manufacturers, and others.

Used in conjunction with any waste
—acid neutralizing process which re-



sults in a suspension of iron oxides and other solids in a neutralized solution. the FEinc continuous filter separates this suspension into easily handled solid cake, and clear filtrate which can be released into streams without danger of acid pollution, it is claimed. The new filter is a special adaptation of the FEinc String Discharge filter that has long given excellent service with commercial iron oxides and pigments. It is simple, sturdy and has low overall operating cost. FEinc design flexibility permits the use of slightly more specialized models in a new neutralization process which yields saleable products.

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Filtering rate of this small model ranges from 60 to 600 lbs. of dry solids per hour, depending on nature of waste liquor and type of neutralizer used. This ample filtration rate results in a substantial quantity of work being handled on a small filter. It works equally well on pickle liquor that as been diluted before neutralization and waste acids that have been used to neutralize waste alkalies before being completely neutralized by the lime or other process, according to the manufacturer. The cake, containing 55 to 75% moisture, can be handled easily by conveyor or truck. The FEinc String Discharge Filter is particularly suitable for recovering cakes that have by-product value.

#### Stainless Steel Chemical Balance

Ohaus Scale Corp., Dept. MF, 10-14 Hobson St., Newark 8, N. J.

The above company announces the availability of its new Triple Beam Balance featuring a stainless steel platform and beams. This equipment is now available through scientific sup-



ply dealers from coast to coast.

The Ohaus Triple Beam Balance is equipped with a stainless steel plate at the point of continuous usage—where all-element resistance is needed. Heat, corrosion, chemicals or accidental sharp blows cannot possibly affect this most durable platform or the stainless steel relief etched beams that give clear, accurate readings, it is claimed.

The balance is particularly suitable for industrial laboratories, school and college "labs", professional and amateur photographers, cosmetic, plastic, surgical and similar industries.

#### Rubber Mats for Lessening Worker Fatigue

Flexi-Mat Corp., Dept. MF, 215 W. Illinois St., Chicago 10, Ill.

The above firm has attacked the foot and leg strain problem for industrial workers who must stand at their jobs all day by developing several types of sponge rubber mats for comfortable

# Now You Can Have Highest Test Pure Water for Plating at only 5¢ per 1000 gallons!

#### **NEW BARNSTEAD**

# **UPFLO** Demineralizers

Have 3 Important Advantages

- New Efficiency Lowers Cost per Gallon
  The combination of improved synthetic resins and the UPFLO method of operation result in much higher purity and at the same time lower operating costs. Depending on the amount of minerals to be removed from the raw water this may well be as low as 5¢ per 1000 gallons.
- Regenerating Time Cut Nearly in Half
  Another adventage of UPFLO operation is that
  "backwashing" is entirely eliminated. This important saving in labor represents a considerable
  reduction in operating costs and further reduces
  the cost of the water.
- Package Unit Easy to Install
  Barnstead UPFLO Demineralizers come completely assembled with all inter-connecting piping, gang-operated valves, and built-in regenerating tanks. They are compact, efficient units, ruggedly constructed with handsome stainless steel cabinets and console type control panels. They need only be connected to raw water supply and waste to start operating. Ready for immediate delivery. Send for Bulletin 117 and prices.

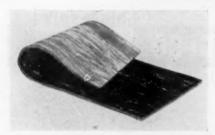


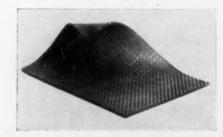
FIRST IN PURE WATER SINCE 1878

235 Lanesville Terraci

**Barnstead**STILL & STERILIZER CO. Inc.

Forest Hills, Boston 31, Mass





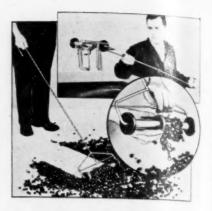
footing. Illustrated in the photo are two of the types available; the stand-

ard sponge rubber mat with a firm tilerubber top surface, and a Neoprene sponge-rubber type for use in locations where resistance to oils is important. Mats are cut to any size or shape from sheets 3 ft. wide and 30 ft. long. Already in use in a number of industrial plants, these mats are proving effective in promoting better employee relations, it is claimed.

#### Rotary Magnets for Floor, Tank and General Uses

Multifinish Mfg. Co., Dept. MF, 2114 Monroe Ave., Detroit 7, Mich.

New loading and releasing principles feature a complete new line of nonelectric Multilift Rotary Magnets now in production. Improved design provides greatly increased carrying capac-



ity plus efficient releasing in retrieving from tanks, separating ferrous from non-ferrous materials, picking up steel from floors, or nails from parking lots, cleaning tramp iron from conveyors and many other purposes.

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The manufacturer states these units will retain their strength forever without charging, requiring no wires or electricity. The Alnico permanent magnets are sealed in a metal tube mounted rigidly between Neoprene wheels in the carrying frame. Handle is attached to frame and unit is rolled; the tube revolves with the wheels and the entire magnetic surface becomes loaded, thus providing capacity greater than when only underside of magnet can be loaded. Capacity depends on size, weight and iron content of load components.

Unloading is accomplished by pushing Neoprene wiper ring to a non-magnetic area at one end, where the load drops off. "Grabbing" tanks is prevented by the wheels; and parts jump up 1 or 2 inches to the tube. The action is equally effective above conveyors.

Multilifts are available immediately in sizes and materials suited to intended uses. For floors, parking lots, etc., tube and frame are brass and 48" handle is steel rod; for tanks or foodstuffs, exposed metal is non-magnetic stainless steel. Standard wheel diameter is 25%, length of smallest model is 91%, larger units being 133%, 18" and 221%. Special sizes to order.

#### General Purpose Hand Truck

General Scientific Equipment Co., Dept. MF, 27th & Huntington Sts., Phila. 32, Pa.

A light-weight, but extremely rugged general purpose hand truck is now available from the above firm.

According to the manufacturer, the



outstanding feature of this hand truck is the two chime hooks, which are adjustable, to lock barrels and kegs of different heights securely in position. Truck is finely balanced so that most of the load is carried on the wheels, thus making it easy to use and handle.

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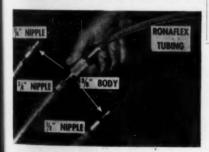
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Regularly furnished with hollowcenter, puncture-proof cushion tires with lug base and Durex self-lubricating bearings. Where acid and oil resistant wheels are needed, the truck can be equipped with aluminum wheels.

Couplings for Flexible Tubing Roniflex Tubing Co., Inc., Dept. MF, Packard Bldg., Phila. 2, Pa.

Increased convenience for the user and substantial reduction in flexible tubing parts inventory are now possible through a design development announced by this firm.

Ronaflex assemblies, the flexible-asrubber, tough-as-steel tubing with snapon couplings, are interchangeable on various nipples. As illustrated, the 3/8" Ronaflex coupling body fits 1/4", 3/8",



and ½" nipples. The ¼" and ½" bodies also fit all three nipples.

The degree of interchangeability varies with the type of coupling and with the size. The  $1\frac{1}{2}$ " and 2" regular coupling bodies, for example, are interchangeable with  $1\frac{1}{2}$ " and 2" nipples. Thus, a limited number of sizes of Ronaflex Assemblies will fit a wide variety of nipple sizes. Only a relatively few sizes of Ronaflex Assemblies need be stocked to fit all sizes of nipples from  $\frac{1}{4}$ " to 2".

# CHRILLE NGIN

# 99.75% PURE

With two complete, independent plants at Jersey City and Baltimore, and over a hundred years of technical background, Mutual is the world's foremost manufacturer of Chromic Acid.



Bichromate of Soda Bichromate of Potash

MUTUAL CHEMICAL COMPANY
OF AMERICA
270 MADISON AVENUE
NEW YORK 16, N.Y.

# **Business Items**

Magnuson Adds New West Coast Salesman

Magnuson Products Corp., 50 Court St., Brooklyn, N. Y., is pleased to announce the addition of Mr. Mort Inglis, to its sales staff representing the corporation in San Francisco and Oakland.

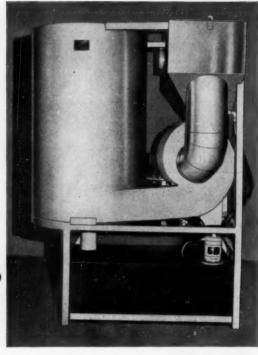
Mr. Inglis, through his experience as a consumer of industrial cleaning compounds, his long experience in the sales and service of these compounds and by his friendly and helpful attitude, is well qualified to assist consumers in that area in the selection



Mort Inglis

# NIEHAUS Dust Separators





The new Niehaus Dust Separator is a complete, easy-to-install unit that employs water action to remove from the air dust and foreign particles resulting from polishing, buffing and grinding operations.

Placed adjacent to machines being exhausted, the Niehaus Dust Separator, by high centrifugal action, thoroughly mixes finely divided particles of water with the dust-laden incoming air and washes out the entrained foreign material.

Refuse is collected in a portable tank beneath the unit . . . clean air is discharged from the top of the machine into the room, eliminating loss of heat.

The new Niehaus Dust Separator combines low first cost and easy operation with constant efficiency and the ability to handle a variety of loads.

Write for complete information.

INDUSTRIAL ELECTROPLATING COMPANY, INC.

and proper use of the proper materials for their requirements.

Warehouse facilities in that area are being expanded to afford prompt service to those in the Oakland-San Francisco area.

#### Pennsalt District Sales Manager Retires; Company Announces Office Consolidation

Frederick G. Rodenburgh, New York District Sales Manager for the Pennsylvania Salt Manufacturing Co., retired July 16 after nearly 50 years of service with the company.

The company, in announcing Mr.

Rodenburgh's retirement, said that effective Monday, July 19, the New York sales office will be consolidated with the Paterson, N. J., sales office, located at 152 Market Street, Paterson, 1.

Mr. Rodenburgh joined Pennsalt in 1899, when he was only 16, as an assistant in the New York sales office. He later became sales agent for the company at the New York office and in 1936 was named New York District Sales Manager.

Charles A. McCloskey, District Sales Manager, will be in charge of the new consolidated office, which will handle Pennsalt sales in Eastern New York State, including the New York City metropolitan area; the New England States, and Northern New Jersey,

Mr. McCloskey, a graduate of the University of Michigan, joined Pennsalt in 1929. In 1931, he was named a sales representative for the New York office and in 1944 was appointed New York District Sales Manager, sharing supervision of the territory with Mr. Rodenburgh. He continued in that capacity until becoming Paterson District Sales Manager.



The Sharlows of Wyandotte

Any way you read, left to right or up and down, the name is William Sharlow. Great grandfather William, Sharlow, grandfather William, father William—all work for Wyandotte Chemicals Corporation at Wyandotte, Michigan. And son William Sharlow—now age six months—probably will too. The Sharlows are one of the 298 father-son and father-daughter combinations now helping produce Wyandotte Chemicals and specialized cleaning materials. The three older Sharlows have already served Wyandotte Chemicals a total of 62 years.

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#### Rolock Inc. Changes Product Designation

Some years ago, Rolock, Inc. of Fairfield, Conn., adopted the name of Processing Carriers for their line of industrial baskets, trays, racks, crates, fixtures, sinks, etc., custom-built for Heat Treating and Metal Finishing

With the development of modern heat and corrosion resistant alloys and new fabricating and welding techniques their market has expanded and demand is being met for fabricated alloy construction of job-engineered retorts, muffles, baskets and other types of equipment which cannot be properly designated as carriers. The term, "Fabricated Alloys," has now been adopted.

Fabrication of heat treating equipment in larger sizes has necessitated a 50% expansion of the Rolock plant, an increase in welding facilities and the installation of new specialized machinery.

Bulletins and Catalog available on request by writing to the above address.

#### Casper Joins General Ceramics

John A. Casper, formerly with National Carbon Co., New York Office, has joined the General Ceramics & Steatite Corp., of Keasbey, N. J., to act as their representative for "Impervite" impregnated graphite equipment and chemical stoneware apparatus as well as steatite insulators and other apparatus for the electrical and radio industry. He will be stationed in the metropolitan area and his territory will extend from New York to Washington, D. C.

#### New Consulting and Research Firm

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Everett M. Patterson and Anthony M. Moos announce the formation of a new company to be known as Patterson, Moos & Company, Inc., Offices and laboratories will be located at 32-36 47th Avenue, Long Island City, N. Y.

This new firm will render a broad scientific consulting service to American industry and will assist clients in the management of research programs and in carrying on fundamental and applied research.

Everett M. Patterson, president, was formerly Chief Engineer and Director or Research for United States Time Corporation and Eversharp, Inc.

Anthony M. Moos, vice-president, was formerly Chief Chemist for R. H. Macy & Co., Inc., and Director of Chemical Research for Eversharp, Inc.

The laboratories of Patterson, Moos & Company, Inc., occupy 8,000 square feet and are divided into four main divisions: Chemical, metallurgical, mecanical, and electrical.

In addition to complete and modern laboratory facilities, the resources of Patterson, Moos & Company, Inc., in-



clude a fully equipped experimental machine shop and facilities for chemical pilot plant production.

# Copper Prices Advanced by Revere

C. Donald Dallas, chairman of the board of Revere Copper and Brass Incorporated, announced that effective July 2, Revere advanced its prices on copper and copper alloy mill products about 5 per cent. This was necessary, Mr. Dallas explained, to take care of an approximate 8 per cent rise in wages now accepted in some plants and offered in the others, and increases in freight rates, supplies and services which have not previously been reflected in Revere prices.

#### Gaspar Appointed Sales Manager of Fan Co.

Mr. C. J. Gaspar, formerly Assistant Sales Manager of the Nicols Wire and Aluminum Co. has recently been appointed Sales Manager of the DeBothezat Fan Division of American Machine and Metals, Inc., of East Moline, Ill. Mr. Gaspar begins his new duties at once, according to Mr. F. C. Weicker, General Sales Manager.

#### Philadelphia Quartz Moves Offices

The Philadelphia Quartz Company announced the removal of its General Offices on August 2, 1948 to the Public Ledger Building, Independence Square, Philadelphia 6, Pa.



For nearly ¾ of a century HENDERSON BROS. has been helping manufacturers solve their Tumble Finishing problems with a wide variety of Tumbling Barrels. . . Sided Wood Barrels, Round Wood Barrels, Perforated, Cast Brass, Cast Iron, Welded Steel Barrels and Rubber Lined Barrels in the Tilt type and Horizontal Type for Bench and Floor installations. Where special processes call for special barrels, Hendersons is prepared to design and construct Tumbling Equipment to customer specification.

Write us, outlining your particular problem.

Our Engineering and Development Service will be glad to make recommendations.



Since 1880 Designers and Builders of Tumbling Barrel Equipment.

THE HENDERSON BROS. COMPANY
135 S. LEONARD ST., WATERBURY, CONN.

#### Turco to Build New Midwestern Plant

Due to the demands of an expanding national market, McCook, Ill., has been chosen as the site of the new, modern plant of Turco Products, Inc., 6135 S. Central Ave., Los Angeles, Calif., manufacturers of specialized industrial cleaning compounds. The new plant is a necessary addition to Turco's present manufacturing facilities at Chicago, Los Angeles and Houston.

Many factors combine to make Mc-Cook an ideal location. Its availability to various sources of raw materials and its central location for distribution of finished compounds makes possible more rapid service and equalization of freight charges to Mid-West and Eastern markets.

#### Brown Adds to Sales-Service Staff

Another increase in the branch and regional sales and service staffs of Brown Instrument Company, Philadelphia, Pa., was announced last month by William H. Steinkamp, field sales manager of the industrial instrument division of Minneapolis-Honeywell Regulator Company.

The latest increase in the field staffs, said Steinkamp, reflects in size the additions which have been made twice yearly since 1945 and further confirms the growth of the company's business and its recently announced expansion of production facilities. The additions to the sales and service staffs and the cities to which each engineer has been assigned were announced as follows:

Atlanta: G. L. Ferguson assigned as a sales engineer.

Baltimore: Wayne Cook and Carl Lower assigned as service engineers.

Boston: Warren N. Smith and Albert E. Phillips assigned as service engineers.

Charlotte: W. Williamson, Jr., assigned as a service engineer and R. J. Holt as sales engineer.

Chicago: Bernard Fuller and Ormond Herring assigned as sales engineers.

Cleveland: R. Schumaker, sales engineer.

Denver: Robert Koening, service engineer.

Detroit: W. DeWolf, service engineer.

Dallas: Robert Harris, Jr., sales engineer.

Houston: C. D. Walker, sales engineer.

Indianapolis: Barry Coleman and Robert Thomas, service engineers.

Los Angeles: Richard Corbin, service, and Ralph Imbrogno, sales.

New York City: A. Godfrey, sales and Ernest P. Lang, William C. Meyer and Edward J. Roach, service.

Philadelphia: A. L. Rogers, Jr., sales, and Albert T. Collins, Joseph Facer and Edward A. Lytle, service.

St. Louis: Keith H. Webb, service.

Syracuse: Richard Caviniss and
George Wilson, service.

Washington, D. C.: John R. Shea.

Kansas City: D. W. Rees, service. Omaha: H. C. Klug, sales.

East Orange, N. J.: William Harris.

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#### Underground Corrosion Exhibit

In connection with comparative field tests of the corrosion resistance of various pipe materials in different types of soils, the National Bureau of Standards has announced an exhibit of approximately 3000 actual test specimens. Chemists, metallurgists, corrosion engineers, and others interested in the behavior of materials underground

are invited to inspect the test samples, which will be on display until August 15, 1948, in the Bureau's Underground Corrosion Laboratory, Connecticut Avenue and Van Ness Street, N. W., Washington, D. C.

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The specimens were exposed at 15 test sites throughout the United States for periods ranging from five to fourteen years. They consist of 8 varieties of materials, including seven types of wrought iron and wrought alloys, 17 types of cast iron and cast alloys, 22 types of steel and steel alloys, 13 types of copper and copper alloys, and miscellaneous samples of lead, zinc, metallic- and nonmetallic-coated pipe, and asbestos-cement pipe. Measurements of loss of weight and depth of pitting of the specimens have been made, and a report on the corrosion resistance shown by the materials studied is in preparation.

# **NEW BOOK**

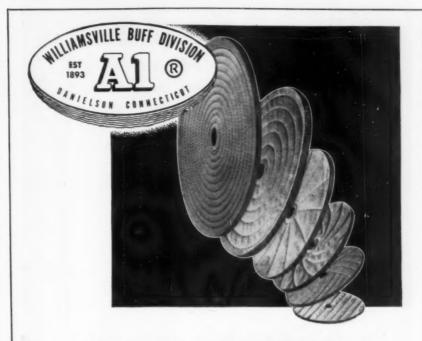
#### Metals Handbook-1948 Edition

Published by American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio, Price \$15,00.

The 1948 edition of the Metals Handbook, now ready for distribution, contains 1444 pages, and is larger in size than any previous edition prepared by member-scientists of the Society. Long accepted as the authoritative source of metallurgical facts, the new edition covers the extended concepts and research which grew out of war production but which, for security reasons, were held in abeyance.

The 1948 Metals Handbook is divided into four principle sections: l. General, 2. Ferrous Metals, 3. Nonferrous Metals, 4. Constitution of Alloys.

There are 74 articles on metals, processes and methods in the general section. Among these are included new summaries of wear, oxidation, stress corrosion, relief of residual stress and service failures. 131 authoritative articles cover ferrous metals, from the manufacture of iron and steel, through shaping, testing, structural properties, welding, heat treating and finishing, to



## If Your Job is Metal Finishing Get This New Reference Book

Hot off the press — here's your catalog of the famous Williamsville Buff Line. It's in two colors, full of photos, and shows a cross-section of the many grades and styles which can help you cut costs and improve your finishing operations. You'll find this new book a valuable reference and time-saver for filling all your metal finishing needs.

Just write us a letter or post card and we'll rush your copy right along! No obligation, naturally.

## WILLIAMSVILLE BUFF DIVISION

The Bullard Clark Company DANIELSON, CONNECTICUT

the practical business of hardening, coating and surface treatment.

There are 102 articles and 220 data sheets about nonferrous metals, including for the first time, discussions of melting, shaping, treating and corrosion. The new 1948 edition of Metals Handbook also contains a new section on the eight precious metals.

The first extensive collection of alloy phase diagrams ever published in America is presented in the Constitution of Alloys section.

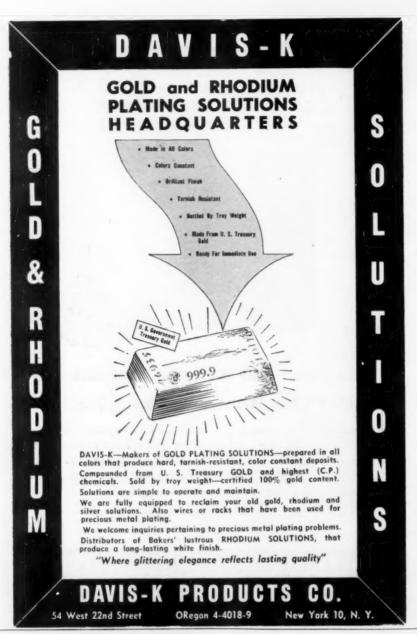
The 1948 edition of Metals Handbook can be obtained by writing the American Society for Metals, at the above address.

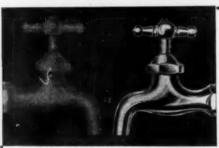
## TECHNICAL LITERATURE

#### Salt Spray Testing

For those who regularly employ the salt spray test to evaluate their finishes and finishing procedures, several points brought out in the A.S.T.M. Report of Committee B-3 at the 51st Annual Meeting are of great importance.

One of these points is the importance of preparing the 20% salt solution from BOILED water. It was found that unboiled water gave rise to a change of pH of the salt solution after it was adjusted to pH 7.0 and placed in the apparatus and maintained





# LUSTREBRIGHT

# BRIGHT NICKEL PROCESS

Produces Brilliant, Lustrous Nickel Deposits.
Eliminates Color Buffing—Re-Cleaning—Re-Racking.
An Ideal Base for Chromium. Excellent Throwing Power.
No Special Solutions or Changes in Equipment Required.
Easy to Control—Low in Cost—Successful—Practical.

Uniform results obtained on all classes of work in still tanks or mechanical barrels. Excellent for zinc die-castings. Your present cold or lukewarm nickel solution will, with the addition of LUSTREBRIGHT, produce brilliant, lustrous, adherent deposits. Guaranteed not to harm

plating solution. Will not cause plate to peel, become brittle, or produce streaky deposits. Illustration shows unbuffed deposits produced before and after addition of LUSTREBRIGHT. Write for complete information.

W. C. BRATE COMPANY

14 MARKET ST.

Est. 1860

ALBANY, NEW YORK

at 95°F for extended periods, one to the elimination of dissolved CO<sub>2</sub>. A change from a pH of 6.9 to 8.7 was recorded after 40 hrs. in one case. As this much change in the pH of the salt solution can materially affect the test results, its importance should not be overlooked in accurate work.

Another surprising thing noted in this report was that certain materials used as containers for the salt solution could also cause a change in the pH. Materials which caused a change were Monel, Nickel, and Stainless steel, while Phenolic varnish coated steel, Koroseal coated steel, or saran did not cause any change. Contact of the salt solution with the former materials is therefore to be avoided during storage of the solution.

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A more complete discussion of these and other pertinent points on salt spray testing may be found in the original report published by the American Society for Testing Materials, 1916 Race St., Phila 3, Pa.

#### Index to 1947 A.S.T.M. Standards

This publication issued in May, 1948, is an adjunct to the 1946 Book of Standards (6600 pages) and the 1947 Supplements (1800 pages), and enables any of the some 1500 standard specifications and tests in the volumes to be located readily. The Index is also of service to those who wish to determine whether A.S.T.M. has issued standard specifications, test methods, or definitions covering a particular engineering material or subject.

All items are listed in the Index under appropriate key-words according to the particular subjects they cover. As a convenience a list is given of the specifications and tests in numeric sequence of their serial designations.

Copies of the 240-page publication are furnished without charge on written request to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

## News from California

Granium Products, manufacturers of "Granium," an additive for silver and gold plating, is now housed in a new plant at Route 1, Saugus, Calif., 30 miles north of downtown Los Angeles.

The new setup occupies a 40-acre tract at Honby Station. R. C. Hub-

hard, owner, has completed a modern laboratory building, 20 x 40 feet in dimension, in which check control of the products is handled. Reduction operations are conducted in the open. The plant is equipped with the most modern facilities as a reduction plant for Granium and other metallic alloys. Land, building and equipment are said to represent an investment in excess of \$125,000. Raw materials are obtained from the lower end of the San Joaquin Valley, east of Bakersfield, from where they are carried by rail direct to the new plant, and from Arizona and several other areas of the Southwest.

The Windsor Chemical Co. has under construction a new plant at 5476 San Fernando Road, Los Angeles, into which the firm expects to have office, manufacturing and laboratory facilities moved in by early August. The firm has been in operation in the San Fernando Valley area of Los Angeles for about 1½ years as a manufacturer of chemical detergents for the finishing industry, and material for surface preparations and allied products. Ray M. Taylor is president, and Dr. M. H. Schweng, vice-president.

Thoro Plate Co., operated at 6260 Romaine St., Hollywood, under the direction of Peter Vale, recently installed considerable new equipment for expanded operations in baby shoe plating. Included among the new equipment are two 36" x 18" x 18" copper sulphate tanks and a dust removing system. Earmarked for early installation are several six-foot tanks. Vale was formerly plating superintendent for Platecraft of California, and prior to that served with Arteraft Platers, Los Angeles.

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A new electroplating setup of 240 foot length has been installed by the Anderson-Carlson Mfg. Co., 1739 213th St., Torrance, Calif., for use in the finishing operations for metallic tubing and allied products. Through a recently completed arrangement, the firm's products will be distributed in the East through Rome Cable Corp. of New York, and on the West Coast, through Pacific Electro Sales, Inc., 2038 Bay St., Los Angeles.

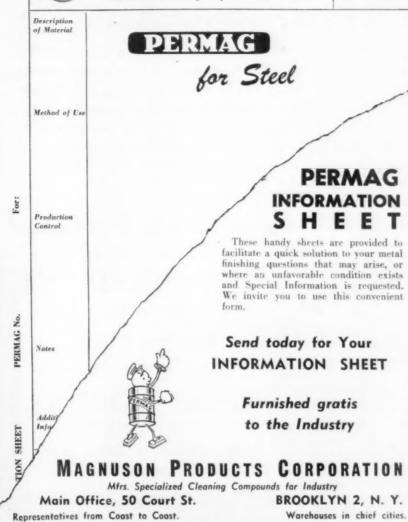
Automatic Polishers, 1821 Randolph St., Los Angeles, has rebuilt and re-



#### INFORMATION SHEET

This information applies only to the specific application outlined for the Permag Compound described below:

FERRO-LYTE



# HARRISON

Buffing and Polishing COMPOUNDS-



# STAND OUT!

In Canada: Canadian PERMAG Products Ltd., Montreal-Toronto

To make your products stand out competitively, specify HARRISON cake or liquid compounds. Their fast cutting and quick cleaning action insure economy of operation.

SPECIAL: Harrison has developed a new dip compound that creates a head on the buff.
You get a deeper cut... use less compound... zave!

At your request, our experienced technical representatives will call to advise you on special problems.

Coment \* Buffs \* Buffing and Polishing Compounds
HARRISON & CO., INC. • HAVERHILL, MASS.



# ONE COAT RACK INSULATION

Now available for all plating shops. BUNATOL No. 1000 Paste Insulation forms a thick and very tough insulation for racks of any size or design. Resists all plating solutions. No cracking or peeling. Lasts for months instead of weeks. If you are not equipped to handle your own racks our nearest licensed Applicator will do your work.

Write for information.

Nelson J. Quinn Co. - Toledo 7, Ohio



# DOMESTIC VIENNA LIME

ROCKWELL BRAND

FOR

COMPOSITIONS

STEEL POLISHING

# ROCKWELL LIME COMPANY

QUARRIES MANITOWOC WISCONSIN OFFICES

228 N. LA SALLE ST.

CHICAGO 1, ILLINOIS

equipped its polishing building which was gutted by fire at a loss of \$250,000 in March.

Now back in operation, the plant is reported by Superintendent Glenn Beckwith to be on four 6-hour shifts per day, seven days a week. The plant, claimed to be the only complete setup in the country for electropolishing aluminum die castings, is at present working on all-aluminum wheel handles, slip-joint nuts, J & L bends and other plumbing parts. All pieces are run on multiple racks. The firm does very little wheel polishing. Its practice is to ball burnish, then apply a heavy copper deposit and follow with about .0015" of nickel.

Typical of the concentration on specialty services which the great postwar expansion in the plating industry has brought about in Southern California is the Hollywood Bronze Supply, Los Angeles. This firm specializes in the manufacture and wholesaling of mountings and supplies for bronzing baby shoes. It provides mountings in onyx, nickel and other types of metal, and also produces and wholesales to job shops such items as rectifiers, agitation systems, lead-lined tanks and other equipment suitable for ornamental coating. Charles Auerback is head of the company.

Los Angeles Parkerizing Co., specialists in rust proofing of sheet metal and machine parts, baked enameling, etc., has announced plans for the erection of a new 16,000 square foot building at 8205 S. Alameda St., Los Angeles.

Alfred Baird, partner with Leo Jorgenson in the Consolidated Buff Co., Los Angeles, was on a business trip to Mexico in June. The firm was established two years ago for the manufacture of sewn buffs and occupies a plant at 6800 S. Main Street. A considerable portion of its raw material is obtained from sisal mills in Mexico. Visits to various mill centers in the southern Republic was the purpose of Baird's recent trip south of the border.

Jorgenson advises us that a reorganization is expected to result in arrangements whereby a well-known eastern firm of established reputation will serve as distributor for Consolidated buffs in the east and middle-west.

Crown City Plating Co., has an-

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nounced plans for construction of new 57 x 67 foot warehouse at 165 S. Fair Oaks Ave., Pasadena.

Dow Chemical Co., Pittsburgh, Calif., has announced extensive plans for expanding its facilities for the manufacture of caustic soda and xanthale. The announcement disclosed it is proposed to spend approximately 31/2 million dollars for two new plants.

Cannon Electric Development Co., has converted a 21,000 square foot warehouse building at 3209 Humboldt St., Los Angeles, adjacent to its main factory, and equipped it for manufacturing and metal finishing of cable terminals, panel boards, electric connectors, solenoids and hospital signal equipment. Plating, polishing, buffing, and assembly equipment has been installed in the former warehouse build-

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Chipman Chemical Co., East Palo Alto, Calif., has announced plans for a plant addition for the manufacture of chemicals.

#### Manufacturers' Literature

#### Fiftieth Anniversary Bulletin

In connection with the celebration

describing the growth and history of the firm since it's foundation in 1898. Interesting photos of all the branches, as well as pictures of the past operations are shown. Copies of the bulletin may be obtained by writing to the above address.

#### High Alloy Stainless Steel for Handling Sulfuric Acid

Duriron Co., Inc., Dept. MF, Dayton 1. O.

An 8 page bulletin has just been issued on a high alloy low carbon austenitic Stainless Steel known as Durimet 20. Introduced just before the war, this alloy has proved to be markedly superior to standard 18-8 stainless steel analyses for certain severe corrosive services, especially in the handling of sulfuric acid.

In the cast form Durimet 20 contains 29% Nickel, 20% Chromium, 13/4% molybdenum, 31/2% copper, 1% silicon and 0.07% Max carbon. In the wrought form the copper and silicon contents are modified slightly.

Durimet 20 is recommended for use with about 125 corrosive solutions. Particular attention is given to the service of Durimet 20 where standard 18-8 stainless steel may be limited in resistance to attack. Its resistance to sulfuric acid and its own limitations for this corrosive are thoroughly



Flexo Wire Company

OSWEGO, N. Y.



# the **Titeflex** Filter will save you money

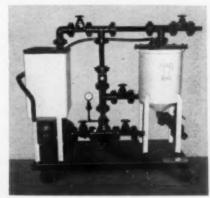
## No replacement parts

The porous filter membrane is a permanent part of the TITEFLEX Filterthere are no expensive filter pads or asbestos sheets to replace. All you need is a few cents worth of filter aid for each batch filtered. You not only save on material costs but also in the time consumed to replace filter pads.

## Completely self-cleaning

To clean the TITEFLEX Filter simply turn a couple of valves to reverse the flow. The "backwash" cleans the filter in ten minutes. Nothing to take out and clean-no mess-no time lost. The valuable man-hours you save can be used for more productive work elsewhere in the shop.

TITEFLEX Filters are compact, highly efficient units that give you sharp, clear filtrates with substantial savings in filter cost. Both portable and stationary models available. Write for descriptive



Our new Model SLA 1000 filter with Saran-lined steel pipe and fittings and rubber-lined filter and precoat tank.

#### Titeflex, Inc.

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70 W. FIRST STREET

#### New Plating Equipment Booklet by Meaker

The Meaker Company, Dept. MF, 1629-41 South 55th Ave., Chicago 50, I/l.

This 36-page booklet just issued describes the Meaker design of automatic, semi-automatic, and special machines for plating and other sequence processing. Included are many illustrations showing the different type machines under diversified operating conditions. A section of the booklet is devoted to plating data tables.

A copy of this booklet may be had by addressing the Meaker Company.

#### **Blast Cleaning**

Pangborn Corp., Dept. MF, Hagerstown, Md.

This booklet consists of 24-pages of pictures, information and performance data on all of Pangborn's various Blast Cleaning and Dust Control equipment and supplies.

Its list of contents covers such items as cabinets, tables, barrels, rooms and special machines—as well as dust collectors, fans, dust wetters, etc. It tells where anyone can find complete

98

details of size and price on any item is, the Pangborn line.

This new Bulletin will be mailed free to persons writing to the above address.

#### **Metal Cleaning**

How an emulsifiable solvent cleaner, in conjunction with pressure-spray washing equipment removes grease, oil, chips, shop dirt, etc., from metal parts between production operations, is described in an interesting article appearing in a recent issue of Oakite News Service, house publication of Oakite Products, Inc., 118 Thames St., New York 6, N. Y.

Oakite Composition No. 97, the article reports, has a duplex action that: (1) quickly wets, penetrates and dissolves oil and grease; and (2) has the ability to lift off the thinned soils and particle dirt, buoying them to the tank surface so that they may be either skimmed or overflowed for disposal. Other particle dirt is so saturated that its attachment to the metal surface is broken and it can, therefore, be easily rinsed away, it is said. Because of the almost neutral pH of Oakite Composition No. 97, it may be used on all

metals, including aluminum, without etching or pitting.

In extensive tests this material has demonstrated the ability to remove dirt and smut particles from metal surfaces where solvent vapor degreasing has failed, the manufacturers state. Other advantages reported are: (1) it eliminates fire and health hazards, because its emulsions are aqueous and non-toxic; (2) it may be used in an industrial washing machine and shows no tendency to foam excessively: and (3) it is admirably suited for removing oils, greases and shop dirt prior to inspection of work in process, or before spot welding, ammonia gas carburizing or electrocleaning before plating. Those wishing to read this article in its entirety may obtain free copies of the issue.

#### Surface Active Agents

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M. Michel & Co., Inc., Dept. MF, 90 Broad St., New York 4, N. Y.

The above firm has just issued a "Guide to Surface Active Agents" which contains colorful diagrams explaining the chemistry of detergents, wetting agents, penetrants, emulsifiers, softeners, etc. Also included are handy



# MARCO No. 410 A NEW DEVELOPMENT

FOR WATER DISPERSION (the shedding of water) AFTER PLATING. FACILITATES DRYING & MINIMIZES ON SAWDUST. In some cases no sawdust necessary if water is hot enough.

GULL CLEANER #67 For washing off tripoli (tallow stearic binder type).

MARCO #110 For washing off buffing compounds (beeswax binder type) and for extra good burnishing results.

GULL CLEANER #100 For still tank soak type cleaning of oil and grease; also for tumble barrel type cleaning.

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charts showing applications and properties of the materials manufactured by the company.

A copy of this Guide to Surface Active Agents is available free by writing to the above address.

#### Practical Nickel Plating

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The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

This booklet is a compilation of existing literature on the subject of Industrial Nickel Plating.

The booklet is a technical one covering the various aspects of nickel plating. Solution compositions and operating conditions are recommended and discussed. Suggested cycles for treatment of the basis metals prior to plating are presented. Plating difficulties, their cause and correction are cited and information on methods of solution purification is provided.

Free copies are available upon request from interested readers.

#### Plating and Finishing Equipment

Randall Mfg. Co., Inc., Dept. MF, 410 E. 93rd St., New York 28, N. Y. The above firm has just issued a new bulletin describing their line of equipment for the electroplating and finishing fields. Described and illustrated are degreasers, conveyorized washing machines, tanks, ovens, plating benches, and many other pieces of modern, efficient machines.

Copies are available by writing the above firm.

#### New Data on Corrosion Resisting Alloys

A new bulletin on nickel-molybdenum-chromium alloys introduced about two years ago by *The Duriron Co., Inc., Dayton, O.*, has just been issued.

This bulletin includes much information on the new Durco alloys, Chlorimet 2 and Chlorimet 3, not previously available. Particular attention is given to its use for sulfuric acid, hydrochloric acid and salt solutions, and on how it supplements other alloys for these corrosives.

Many charts are included on corrosion resistance tests. One hundred and twenty corrosives altogether are dealt with.

Chlorimet 2 and Chlorimet 3 are available in cast form. Durco-pumps

and valves are now regularly supplied in these alloys,

#### Selenium Rectifiers

Richardson-Allen Corp., Dept. MF, 15 West 20th Street, New York, N. Y.

An eight-page catalog in color describing, illustrating, and giving engineering data on a complete line of Selenium Rectifiers for electro-platers, electrotypers, anodizers and all other industrial users of AC to DC power conversion equipment is announced by the above firm.

Units covered range from 6 volts to 28 Volts with maximum of 4000 Amperes in a single cabinet, and include basic models, remote controls, self-centained units and many special purpose units. Tables show ratings of the wide range of models available and wiring diagram shows graphically necessary hook-up information.

#### **Metal Cleaning**

Metal - Clean Solvent Corp., Dept. MF, 1935 N. Paulina St., Chicago, Ill.

Valuable information on the production cleaning and conditioning of ferrous and non-ferrous metals is

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available in a new 24-page booklet issued by the above firm.

This informative booklet, entitled "The Inside Story," tells how Metal-Clean solvent cleaners offer a means of keeping rejects down and achieving the high standards of production, inspection and assembly so important to the quality of the finished product, and also how the application of these solvents is practical for the most difficult problems of soil removal.

A description of "soil controlled" cleaning explains the action of these cleaners, which operate by an intricate system of dispersion, emulsification, and suspension. Listed among the numerous advantages of "soil controlled" cleaning are: the elimination of fingerprinting during assembly operations, rust inhibition after cleaning, and the consistent production of "bright, spot-free parts, physically clean and ready for any subsequent finishing operation."

Free technical advice, based on the latest and best metal cleaning practice, is also offered in the booklet.

## Letter to the Editor

Finishing Publications Incorp. 11 West 42nd Street New York 18, New York

Editor:

In regards to the problem of salvage of metals from Dummy Cathodes from HMC in the June 1948 issue of METAL FINISHING, I would suggest that if it were possible to use Dummy Cathodes which have a smooth copper or brass surface before plating, it would be easy to give them a light wash with sodium sulphide solution just before plating on the first layer of material. After one hundred to one hundred and fifty layers of copper and nickel have been accumulated it will be found possible to slit the accumulated plating material lengthwise of the cathode and peel the entire accumulation off in the form of a sheet.

If it were decided to recover the nickel, for instance, in the form of small flakes, this sheet of plated material could be cut into ribbons on a

shear and these ribbons cut into little squares or diamonds by crosswise shearing and the copper removed by treating the little squares with Ferric Chloride solution while agitating it vigorously with a stream of compressed air blown into the solution.

This will result in a solution of copper and a remainder of flaked nickel, and the purity of the nickel should be very good. This process has been in use for many years in a commercial way and is thoroughly practical excepting that it still remains to recover copper from the solution. This is not at all difficult; or the solution may be somewhat boiled down by waste heat and sold as a concentrate.

The main essential of this plan is to use a stop-off varnish on the bottom end of the Cathode so that the plating material will not be able to secure a grip around the edge of the Cathode, but will adhere only to the vertical surface, from which it will be easy to strip it if a good coat of copper sulphide has been developed before plating starts.

Yours very truly, C. W. B.

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# **Associations and Societies**

# AMERICAN ELECTROPLATERS' SOCIETY

At the Annual Convention of the AES held recently at Atlantiy City, awards were presented to those branches that had achieved the highest number of new members for the year. The branches were awarded permanent possession of large silver loving cups in honor of their achievements. The results announced at the annual banquet that was held at the conclusion of the convention were as follows:

First Division, Pittsburgh Branch. Second Division, Rochester Branch Third Division, Cincinnati Branch.

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Awards for the best exhibits of plated ware by the branches were won by the following:

First Prize \$150, Columbus Branch. Second Prize \$100, Twin City Branch. Third Prize \$ 50, Buffalo Branch,

The \$50 award for the best individual exhibit of plated ware was won by Mr. Harold Narcus of the Boston Branch.

The Chas. H. Proctor Award for the best paper delivered at the Technical Sessions was given to Dr. Abner Brenner and Seymour Senderoff, of the National Bureau of Standards, for their paper on "The Spiral Contractometer—A New Instrument for the Measurement of Stress in Electrodeposits."

The Founders Gold Medal for the best paper of the year was awarded to Mr. Ralph McCahan and Mr. C. E. MacKinnon for their paper on "Diaphragm Tanks to Eliminate Roughness in Copper Plating."

The AES Gold Medal for the best paper by a member of the AES that appeared in *Plating* for the year was awarded to *Mr. E. J. Roehl* for his paper on "The Mechanical Properties of Nickel Deposits."

The award for the best paper to appear in the Society magazine *Plating* for the year went to *Mr. C. F. Nixon* and *Mr. R. C. Olsen* for their article on "Nickel and Chrome Plating."

#### Melbourne (Australia) Branch

The 34th regular meeting of the Melbourne Branch was held in the Chamber of Manufactures on June 28, and was attended by 45 members and 7 visitors. One application for membership was received and referred to the Board of Managers, and business of interest included a report from the Secretary relating to our Food for Britain drive.

The guest speaker was Dr. A. M. L. Murray, who spoke on "Health Hazards in the Plating Industry," an address with a wide appeal which was heard attentively by all present. Amongst many points made by the speaker were these; that the electroplater is exposed to fire, explosion and machinery hazards as well as physiological hazards, therefore, he should be exceptionally safety conscious, When discussing the effects of dust on personnel having regard particularly to possible lung damage. Dr. Murray stressed that there was no real danger to be feared from particles larger than 5 microns in size, which means that the

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Because they are impervious to moisture, vapor and the fumes of most common acids, PC Solid Glass Blocks are ideal insulating supports for acid or electrolytic tanks. These solid glass units are

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No. 650 Vapor-Line Control

No. 600 Tank Temperature Controls

No. 550 87 Trap-Control

Nos. 350 & 450 Bucket, Thermostatic and Float-Thermostatic Steam Traps

No. 1200 Pipe Line Strainers

ASK FOR THE SARCO CATALOGS ON PLATING



dust that can be seen is not really dangerous-it is the unseen which matters. Later while discussing skin diseases the speaker mentioned that the adage "Prevention is better than cure" applies most particularly to prevention of onset of dermatitis.

#### ASTM

#### R. L. Templin Elected New President

Richard L. Templin, Ass't Director of Research and Chief Engineer of Tests of The Aluminum Co. of America was elected to the presidency of the ASTM for the coming year. Other officers elected at the Annual Meeting held

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in Detroit recently are L. J. Markwardt. Ass't Director U. S. Forest Products Lab., vice-president; Leslie C. Beard, Jr., Ass't Director of Laboratories, Socony-Vacuum Oil Co., Board Member; Simon Collier, Director of Quality, Johns-Manville Corp., Board Member; Theodore P. Dresser, Jr., Chief Engineer, Abbot A. Hanks, Inc., Board



Member; Howard K. Nason, Associate Director Central Research Dep't., Monsanto Chemical Co., Board Member; and Edgar W. Fasig, General Sup't

Mr. Templin graduated from the University of Kansas, receiving his degree of B.S. in Civil Engineering in 1915. For post graduate work at the

Lowe Bros. Co., Board Member.

University of Illinois he was awarded the degree of M.S. in Theoretical and Applied Mechanics in 1917. After two vears with the National Bureau of Standards in Washington, D. C., Mr. Templin came to Pittsburgh in 1919 to join the staff of the Aluminum Company of America, as Chief Engineer of Tests. Since that time he has had the additional responsibility of Assistant Director of Research, beginning in 1942. Throughout these years he has been personally responsible for the development of many of the testing methods that are used today in the inspection and quality control of aluminum products. A member of numerous A.S.T.M., A.S.C.E., and A.S.M.E. committees, Mr. Templin holds a number of patents on aluminum fabrication and testing equipment, and is the

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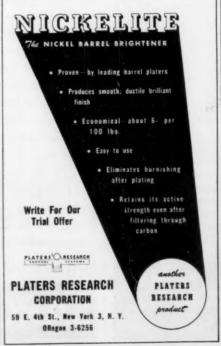
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author of many papers and reports describing work in the non-ferrous and other fields.

In June, 1934, the American Society for Testing Materials awarded Mr. Templin the Chas. B. Dudley Medal for his outstanding research paper on "Fatigue." In October, 1936, he was awarded jointly with Mr. A. V. Karpov, the Thomas Fitch Rowland prize for a paper describing the building and testing of a model of the Calderwood Arch Dam. In 1940 the Franklin Institute of Pennsylvania gave him the Edward Longstreth Medal for his development work in the field of deformation recording apparatus.

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#### ELECTROCHEMICAL SOCIETY

The fall meeting of the Electrochemical Society will be held at the Hotel Pennsylvania, New York, N. Y., on October 13-14-15-16, 1948.

Technical sessions will present the opportunity to participate in discussions on Electrodeposition of Metals, Electrolytic Production of Metals, Batteries, and General and Theoretical Electrochemistry.

#### FOURTH ANNUAL CLEVELAND SYMPOSIUM

Sponsored Jointly by the Cleveland Sections of

American Chemical Society American Institue of Chemical Engineers

#### Electrochemical Society

Surface Chemistry in various aspects will be covered in the Fourth Annual Cleveland Symposium scheduled to be held at the Hotel Carter, Cleveland, on September 25, 1948. The program will include the follow-

Morning Session-Starting at 10:00 A.M.

Crystal Structure and Surface

Dr. A. T. Gwathmey, University of Virginia

Developments and Trends in Industrial Catalysts

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Dr. J. H. Boyd, Consultant Surface Reactions of Magnesium as an Anodic Material

Mr. W. S. Loose, Director Laboratory Development Division, Magnesium Laboratories, Dow Chemical Company

Luncheon Afternoon Session-Starting at 2:00 P.M.

Phosphate Coating of Metal

Mr. V. M. Darsey, President, Parker Rust Proof Company

Principles of Powder Metallurgy

Mr. H. C. Miller, Vice President, Charles Hardy, Inc.

New Developments in Organosole and Plastisole

Mr. C. W. Patten, Manager Coating and Adhesive Materials Division, Thermoplastics Department, The Bakelite Corporation

Further information may be obtained from Mr. K. S. Willson, The Harshaw Chemical Co., 1945 East 97th St., Cleveland 6, Ohio.

#### AMERICAN CHEMICAL SOCIETY

Fifteen thousand chemists and chemical engineers will participate in the 114th national meeting of the American Chemical Society, which will be held in three sessions in Washington, D. C., St. Louis, Mo., and Portland, Ore., August 30 to September 17, it is announced by Dr. Charles Allen Thomas, president of the Society.

The Eastern Session, in Washington. will run from August 30 to September 3; the Midwest Session, in St. Louis, from September 6 to 10, and the Western Session, in Portland, from September 13 to 17.

The divided national meeting, first in the Society's seventy-two-year his-



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tory, was arranged to enable the maximum number of the 57,000 members to attend.

Recent developments in virtually every field of chemical science and technology will be reported in several hundred papers. Seven awards for outstanding achievement, including the Priestley Medal, highest honor in American chemistry, will be presented at the meeting.

"Chemicals for Agriculture" will be one of the principal topics of the Washton meeting. Improvements in the manufacture of medicinal chemicals



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#### HAMILTON

EMERY & CORUNDUM COMPANY Chester

will also be reported on. "Chemical Marketing" will be the theme of another important symposium.

Three awards will be presented at a general assembly in Washington on Monday night, August 30. The Francis P. Garvan Medal honoring women in chemistry will be given to Dr. Gerty T. Cori of the Washington University School of Medicine, St. Louis, 1947 Nobel Prize Winner in medicine, for her work in biochemistry. The Eli Lilly & Company Prize in Biological Chemistry will be presented to Dr. Dilworth Wayne Woolley, 33-year-old blind scientist of the Rockefeller Institute for Medical Research, New York, for studies of problems relating to vitamins and antivitamins. The third prize winner will be Dr. Albert L. Lehninge, assistant professor of biochemistry in the University of Chicago's departments of surgery and biochemistry, who will receive the Paul-Lewis Laboratories Award in enzyme chemistry for his research on the chemistry and metabolism of fatty acids.

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New discoveries and techniques in the fields of plastics and coatings will be reported at the Washington sessions of the Division of Paint, Varnish and Plastics Chemistry. The Division of Organic Chemistry also will meet in Washington.

The St. Louis meeting, opening Monday, September 6, will hear reports on the relationship of fuel properties to engine design, the future of high octane gasoline, developments in municipal water purification and recent research in high polymers, the giant

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#### FREE BOOKLET.

ON G-E AUTOMATIC TANK VOLTAGE CONTROL Booklet gives dimensions on all rectification equipment for easy planning. Describes push-button control box for control right at the tank—automatic "on-load" control holds voltage within  $\pm$  2%. For a copy of Copper-oxide Rectifiers and Controls. write to Section A16-853, General Electric Company, Bridgeport 2, Conn.

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molecular structures making up plastics, rubbers and fibers.

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America's top chemistry honor, the Priestley Medal, will be presented at St. Louis to Dr. Edward R. Weidlein. director of the Mellon Institute for Industrial Research, Pittsburgh. Another award presented at this meeting will be the newly established Fisher Award in analytical chemistry, which will go to Dr. N. Howell Furman, Russell Wellman Professor of Chemistry at Princeton University, for "his substantial contributions" to analytical chemistry and particularly his studies on electrometic techniques in chemical analysis.

Important advances in petroleum research, production techniques and products will be described in a session on "Additives for Petroleum Products."

Municipal water supply and sewage problems will also be discussed.

Recent achievements of the nuclear chemist in the field of atomic energy, of the biological chemist in animal nutrition, and of the wood chemist in deriving sugars from wood will be stressed at the Portland meeting from Monday, September 13, through Friday, September 17.

#### SOCIETY OF THE PLASTICS INDUSTRY.

The Society of the Plastics Industry will stage its Third National Plastics Exposition in Grand Central Palace, New York, Sept. 27-Oct. 1, inclusive. It is being planned as a purely trade and industrial show, emphasizing recent strides made by the plastics industry in a number of hitherto unexplored

A greater attendance of business representatives and prospective buyers is expected for next fall than at either of the preceding shows, since admission will be by invitation and registration

#### AMERICAN OIL CHEMISTS' SOCIETY

The American Oil Chemists' Society will hold its Fall Meeting in New York City at the Pennsylvania Hotel, with technical sessions on November 15. 16, and 17, 1948, followed by plant trips on the 18th. This is the first time for over 10 years that a meeting of the society has been held in New York City.

Present plans call for technical papers, plant inspection trips, group meetings, and a banquet. A special feature of the meeting will be the availability of space for exhibits. The exhibits are in charge of Dr. R. H. Rogers, Jr. The General Chairman is Dr. Foster D. Snell, of Foster D. Snell.

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Are woven and prepared to give you these outstanding advantages

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-300 Ampere, 15 V. Star.
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-800 Ampere, 22/33 V. Gen. Elec.
-1500 Ampere, 24 V. Elec. Prods.
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-200 Ampere, 32 V. Gen. Elec. -1500 Ampere, 32/40 V. Elec. Prods. -1000 Ampere, 33 V. Gen. Elec. -200 Ampere, 42 V. Gen. Elec. -1500 Ampere, 45 V. Century. -1500 Ampere, 50 V. Gen. Elec. -800 Ampere, 50 V. Gen. Elec. -400 Ampere, 50 V. Gen. Elec. -1500 Ampere, 50 V. Gen. Elec. -1500 Ampere, 50 V. Gen. Elec.

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